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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

Initiation Fees		*Annual Dues*	
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This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

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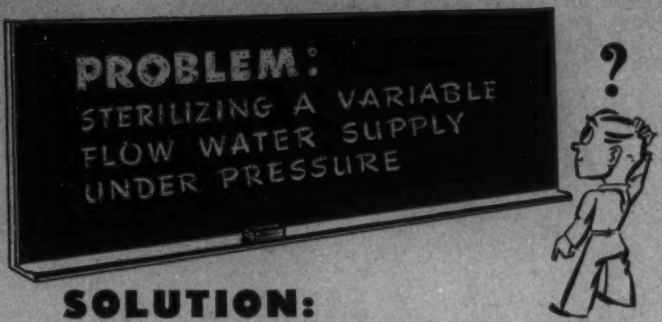

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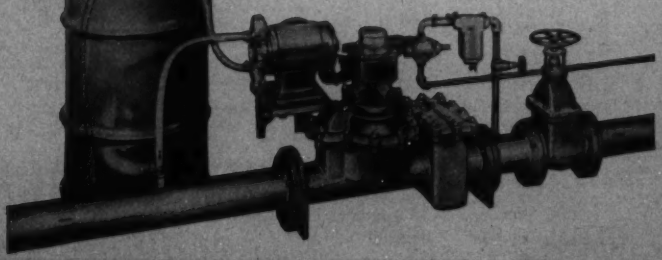

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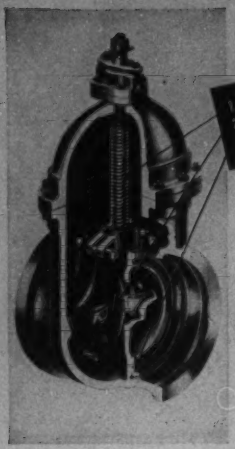

1. Continued turning of valve stem
2. Brings wedges into action and expands the discs against their seats
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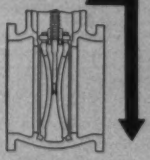

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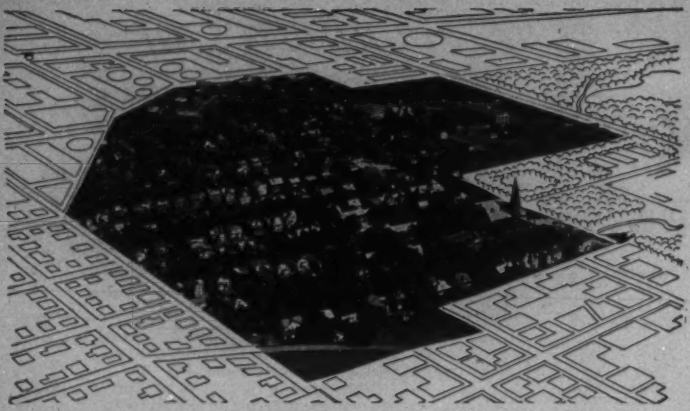

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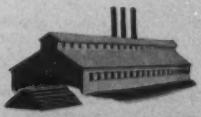

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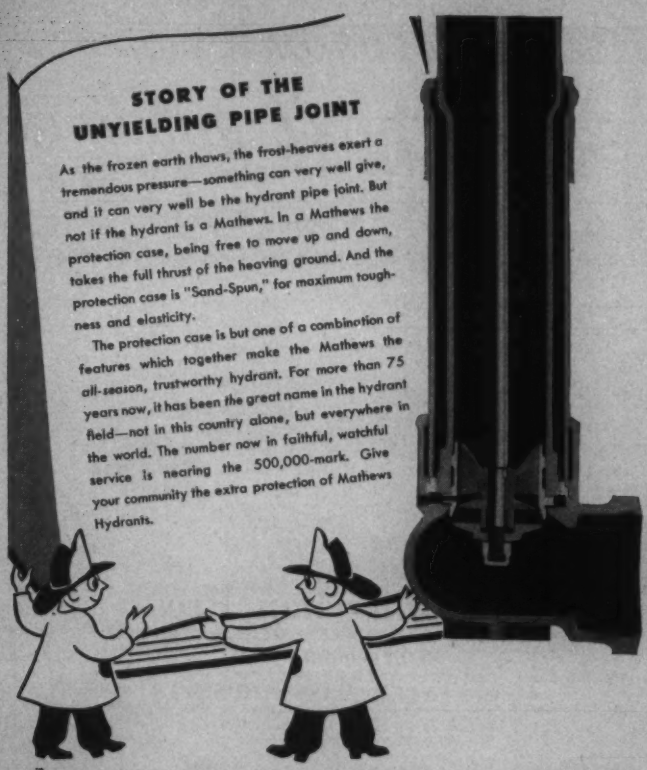

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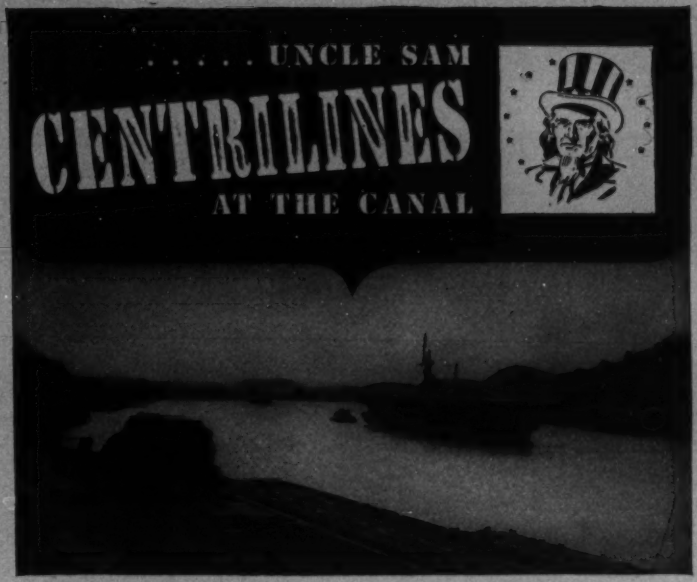

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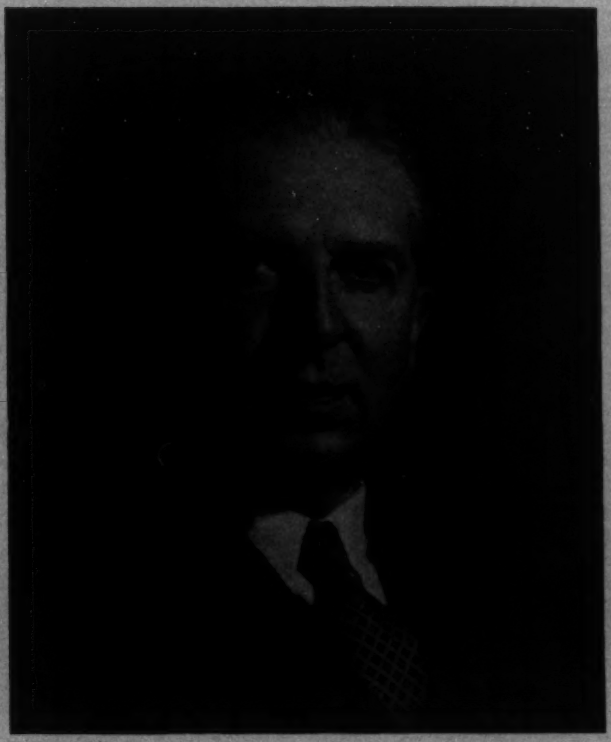

Photo by Grant V. Kierstead

ARTHUR L. SHAW

President of the New England Water Works Association 1946-47

New England Water Works Association
ORGANIZED 1882

VOL. LXI MARCH, 1947 No. 1

This Association, as a body, is not responsible for the statements or opinions of any of its members

TORONTO WATER-WORKS EXTENSIONS—A GENERAL DESCRIPTION OF THE SYSTEM WITH DETAILS OF SOME OUTSTANDING FEATURES

BY WILLIAM STORRIE*

[*Read September 19, 1946.*]

Toronto, a name of Indian origin, denoting "a place of meeting," is situated on the north shore of Lake Ontario, about 40 miles from its western end. It began as a village at the mouth of the small River Don, where a sand bar, now called Toronto Island, enclosed a natural bay. From a land area of less than 9 sq mi and a population of 9,254 persons in 1834, the city in 1946 has grown to a land area of 34 sq mi and a population of 696,555 persons. In addition to this urban population, there are some 200,000 persons within the Toronto and Suburban Area but residing outside of the city limits, most of whom secure water from the city's system.

The enclosed portion of Toronto Bay is roughly 2 miles long by 1 mile wide. It is almost completely land-locked, with dredged entrances some 400 ft wide at the northwestern and southeastern corners. The central portion of the basin is 20 to 30 ft in depth. Except where deepened by dredging, the water along the mainland shore is shallow, reaching a depth of 16 ft at a distance of ¼ mile, more or less.

East of the turning basin and south of the mainland, there is a rather extensive area of shallow water and marsh, known as Ashbridge's Bay. It is about 1 mile long and ½ mile wide at the widest part. It formerly extended westerly nearly to the harbor but much of the area has been reclaimed for industrial and harbor developments.

The existing Eastern Avenue sewage treatment plant is situated on the north shore of Ashbridge's Bay and, at the present time,

*Consulting Engineer, Gore & Storrie, 1130 Bay St., Toronto 5, Ontario, Canada.

there is under construction a sewage treatment plant for the city on the southern shore of Ashbridge's Bay and fronting on Lake Ontario.

For many years previous to 1941, the water supply for the city was secured through two intake pipes situated in Lake Ontario, with two water purification plants on Toronto Island. The water is pumped from suction wells to the water purification plants. This supply is chlorinated and at times superchlorinated, in accordance with the quality of the raw water.

In 1941 a duplicate system costing $14,000,000 was placed in operation. The source of supply is just outside the easterly limits of the city. Water is secured through an intake, placed in water 50 ft in depth, at a point about 7,200 ft off-shore from Victoria Park. Here the raw water is treated by coagulation, rapid sand filtration and chlorination.

The purpose of this paper is to describe in a general way the main features of the extensions to the water-works system and to give a more detailed description of some of the unusual features embodied therein. The scope of the work covers too wide a field to attempt adequately to describe in detail all the varied phases of the scheme.

Victoria Park having been agreed upon as the best location for a raw-water intake, the other main features of the scheme were developed so that the system now consists essentially of the following:—

(a) At Victoria Park an intake tunnel 10 ft in diameter, constructed in shale and extending from the shore out underneath the lake bottom a distance of 3,300 ft, into a 30-foot depth of water, and terminating in a submerged tunnel shaft. This tunnel has a maximum capacity of 300 mgd.

(b) From the end of the tunnel shaft provision has been made for the laying of three concrete-lined steel intake pipes, only one of which has been laid, this being 8 ft in diameter and 4,172 ft in length, terminating in a 50-foot depth of water. The 8-foot pipe installed has a capacity of 125 mgd. The other two pipes will be laid as and when the demand arises.

(c) At Victoria Park a low-lift pumping station, coagulating basins, filters, reservoir, general offices and laboratory, with provision for treating initially 100 mgd and so laid out as to permit of this capacity being at least doubled in the future.

(d) At Victoria Park a high-lift pumping station for supplying all that area lying east of the Don River.

(e) From Victoria Park the distribution mains for connecting to the existing mains and also additional feeder mains for supplying the area lying east of the Don River.

(f) From Victoria Park a concrete-lined filtered-water supply tunnel, 7 ft in diameter and 31,087 ft in length, constructed through shale to the existing main pumping station at John Street.

(g) From John Street station a concrete-lined filtered-water tunnel, 6 ft in diameter and approximately 18,575 ft in length, constructed through shale to a point on the Lake Shore Road, north of the Canadian National Railway tracks and immediately east of Parkside Drive.

(h) At the southeast corner of St. Clair Avenue West and Spadina Road, a covered reinforced-concrete reservoir with a storage capacity of 50 mil gal, for supplying Districts Nos. 2 and 5.

(j) The necessary connecting mains to and from the St. Clair Avenue-Spadina Road reservoir and elevated tank.

In order to complete the scheme the following additions will be made as necessity arises:—

(k) At Parkside Drive a high-lift pumping station for supplying the western and northwestern area of the city and, further, to serve as a connecting link to the contiguous northern areas now served or to be served.

(l) From Parkside Drive high-lift pumping station, a 42-inch diameter distribution main, running northward to connect to the existing system in District No. 2, and a 30-inch diameter distribution main to District No. 1.

(m) At the St. Clair reservoir site an elevated storage tank with a capacity of 500,000 gal for supplying District No. 3.

Existing Supply

The existing water-supply system of the city of Toronto and surrounding district covers an area of about 46 sq mi. The area of supply stretches along the northern shore of Lake Ontario, a distance of about 10 miles, and to the north a distance of about 8 miles, measured from the water purification plants on Toronto Island. The ground surfaces within the area of supply rise more or less gradually to the north to a height of nearly 400 ft above the lake level. The difficulty of maintaining the proper pressures in the service pipes, therefore, lies both in the loss of head by friction in the pipes over the long distances traversed by the water and in the rising elevations

Note—Wherever the word "gallon" is used the Imperial gallon is meant. An Imperial gallon is equal to 1.2 U. S. gallons.

of the ground surfaces, the more distant areas being at greater elevations. To meet this situation, the water-supply area hitherto has been divided into seven districts with fairly uniform pressures in each. The new works are so laid out as to reduce the number of districts to five, one of which is on Toronto Island and is supplied directly from the water purification plants there. Figure 1 shows a general layout of the completed system.

Districts Nos. 1 and 2 are supplied from the existing John Street pumping station and from the new pumping station at Victoria Park. Districts Nos. 3 and 4 are supplied by boosting the pressures from Districts Nos. 1 or 2. The supply in District No. 1 is balanced by the Rosehill service reservoir and, similarly, the supply in the enlarged District No. 2 is balanced by the St. Clair service reservoir. A new overhead tank, to be ultimately constructed, will balance the supply in District No. 3 and the existing standpipe in District No. 4 has been enlarged to a capacity of 500,000 gal to balance the supply within this district. Thus the new works will supply water directly or indirectly at both ends and towards the middle of both Districts Nos. 1 and 2. The balancing reservoirs are situated almost in the centre of the districts to be supplied in an easterly and westerly direction but outside of these districts and to the north in order to secure higher elevations than exist within those districts. A diagrammatic layout of the complete system, showing the elevations of the various water districts, will be found in Figure 2.

The original water-works system consists essentially of two 6-foot diameter submerged intakes, with one of the inlets located in about 43 ft and the other in about 79 ft of water off Centre Island and about 2,190 ft and 2,383 ft, respectively, from the shore. The water is pumped from the intakes to either the slow sand or the drifting sand water-purification plants at Centre Island, having a combined nominal capacity of 100 mgd. A 7-mil gal reservoir adjacent to the filters holds the filter effluent and from this reservoir the water passes through two steel pipes, 7 ft and 6 ft in diameter, respectively, laid across the Island to a tunnel shaft. These pipes are connected to a tunnel, having a section equivalent to 8 ft 4 in. in diameter, which leads underneath Toronto Bay to the suction wells at the foot of John Street, where the main pumping station is located, and the water

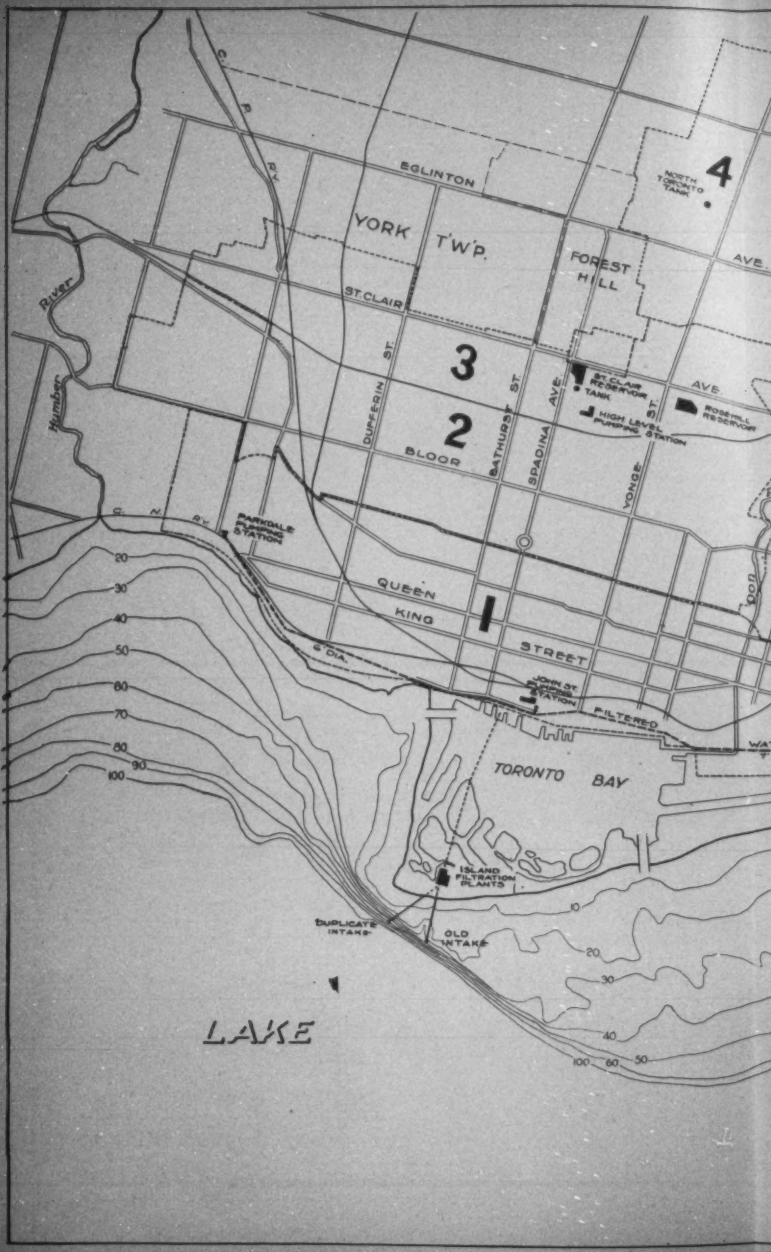

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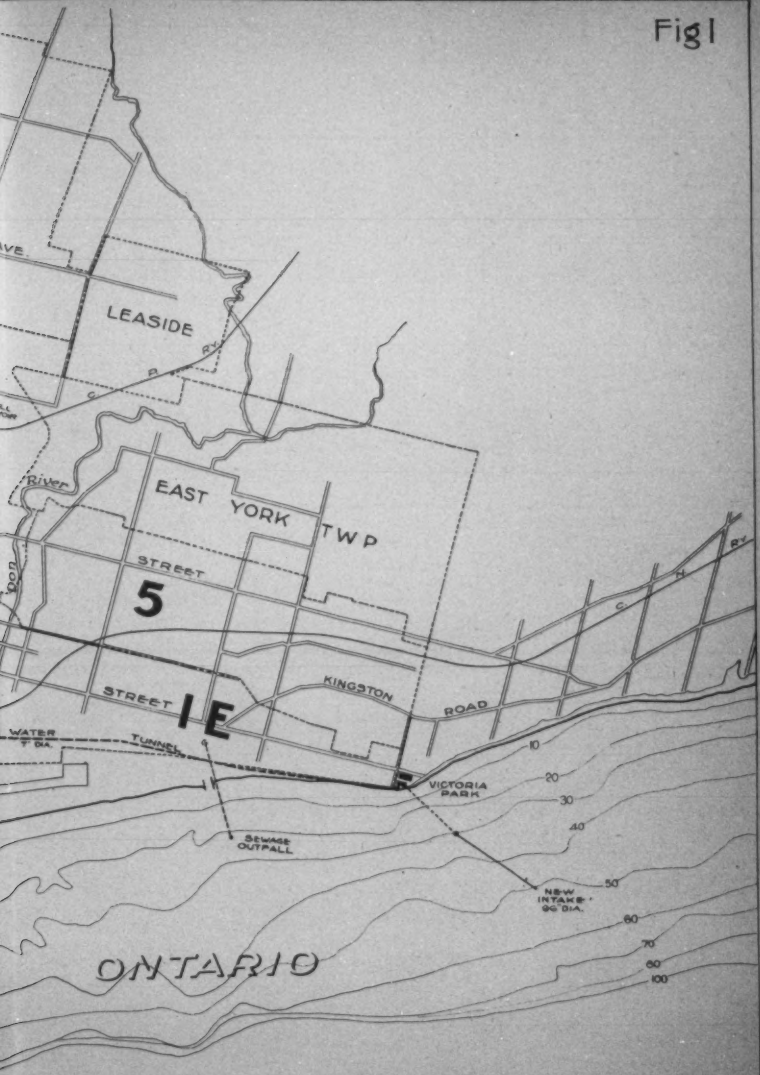
Fig 1

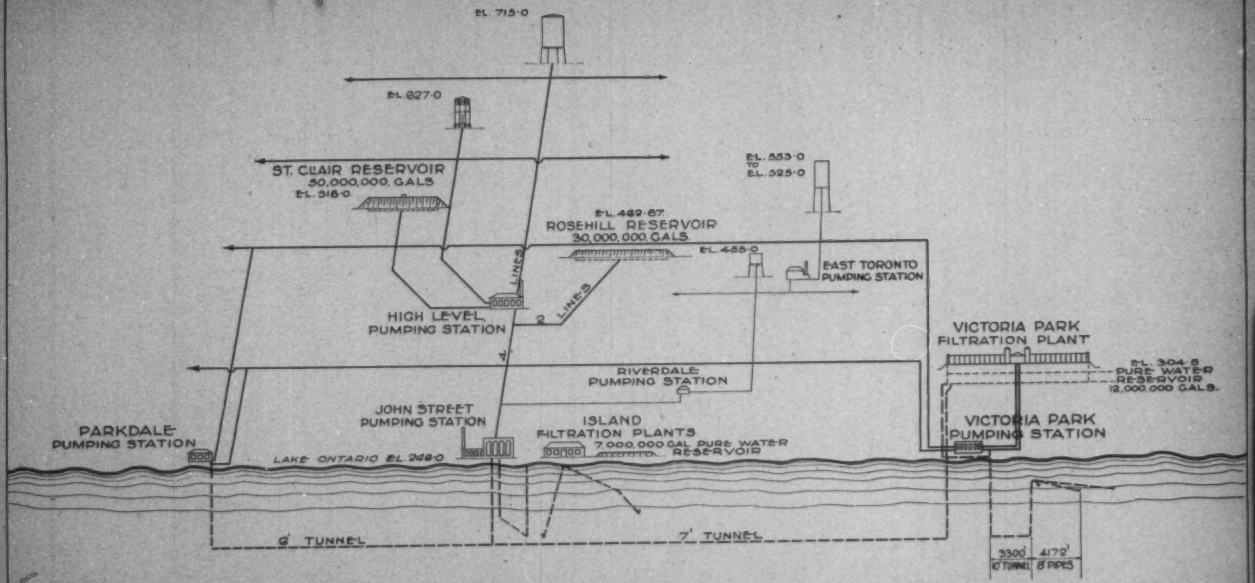


TORONTO WATERWORKS EXTENSIONS

GENERAL LAYOUT OF SYSTEM

SCALE

Fig2



TORONTO WATERWORKS - DIAGRAM SHOWING ELEVATION OF WATER DISTRICTS

is there pumped into the distribution system throughout the city. The pumping station at John Street has a total installed pumping capacity of 212 mgd, pumps with a capacity of 102 mgd being steam-driven and those with a capacity of 110 mgd being electrically operated.

From the John Street pumping station the distribution system radiates throughout the city through eight mains, seven of 36-in. diameter and one of 30-in. diameter. The operating pressure on the pumps is 102 lb per sq in. Filtered-water storage reservoirs are provided at Rosehill, with a capacity of 38 mil gal, and at St. Clair, with a capacity of 50 mil gal.

The water supply is chlorinated at the Island only. Dechlorination with sulphur dioxide for the removal of taste, when necessary, is carried out at the John Street pumping station.

High-Pressure Fire System

In the central business section of the city a high-pressure fire system was established in 1909 and is paid for as a fire department charge. There are 10 miles of mains serving 337 acres in the congested business section. Any pressure up to 300 lb per sq in. can be maintained during fire periods. Normally a pressure of 100 lb per sq in. is automatically and continuously maintained on the mains. This system has 173 hydrants which are tested to 700 pounds pressure. There are 3 steam turbine pumps, having a combined capacity of 20 mgd, located at the John Street pumping station. The water for the system is drawn from Toronto Bay and is entirely separate from the domestic supply.

Operating Difficulties

Over a long period of years many operating difficulties arose, particularly at the source of supply. In 1874 a 48-inch wood-stave pipe, laid across the Island and in the lagoons, rose to the surface, due to being laid without cover. In 1877, owing to the inadequacy of a filter basin, channels were cut through to the lake. Wooden conduits leading from these channels became choked at times of storms. In 1892 sections of the conduit in the bay near the Island rose to the surface, in consequence of the pipe being emptied by the

John Street pumps while it was blocked at the Island screens by weeds. In 1895 further breakage occurred in supply conduits, due to the accumulation in them of sand and other obstructions, coupled with the extremely low water level then prevailing in Lake Ontario. In 1898 a 72-inch steel intake pipe was laid and in 1908 a horse-shoe-shaped tunnel, 5,087 ft in length and equivalent to 8 ft 4 in. in diameter, was constructed under the floor of Toronto Bay to the John Street pumping station.

In 1910 and early in 1911, breakages occurred in the 72-inch steel intake pipe. These breakages were caused by ice piling up on the fore-shore and, when the ice field moved, the intake pipe was carried with it. This pipe was repaired and reinforced by the driving of steel piling on each side of the pipe and placing concrete around the pipe for a distance of 1,200 ft from the shore. A second 72-inch steel intake was constructed in 1913. Since 1911 intake trouble has been experienced on only one occasion, when a break occurred in the old intake in 1921, just south of the point where the steel piling and concrete protection placed in 1911 terminated.

Toronto Island has been built up in part by the disintegration of Scarborough Bluffs, lying to the east of Victoria Park. The loosened material appears to be carried in a westerly direction towards Toronto Island and, in consequence, the two intakes south of the Island are affected by the piling-up of sand around the intake inlet. From time to time this sand has to be removed by dredging. Erosion has taken place in many sections. It will thus be seen that, in the construction of the Victoria Park intake, an altogether different type of intake had to be established in order to eliminate, as far as possible, the difficulties already enumerated.

Intakes

The greatest hazard in the operation of intakes in Canada is that due to frazil ice. On bodies of water subject to wave action, in which the sheet ice is broken up during its formation, frazil ice is formed and may be drawn into the intake by eddies or other currents. With low temperatures and high winds, this ice may be formed in such quantities as to shut off completely the supply of water. Anchor ice which forms on the bottom, or on the intake itself if the water

temperature at that point becomes sufficiently low, may also cause trouble. If the intake is located near the mouth of a stream, floating ice may be brought down by flood waters in such quantities as to interfere with the operation of the intake. As ice is only slightly lighter than water, only a slow current is required to cause it to flow with water, particularly if it has been broken into small pieces.

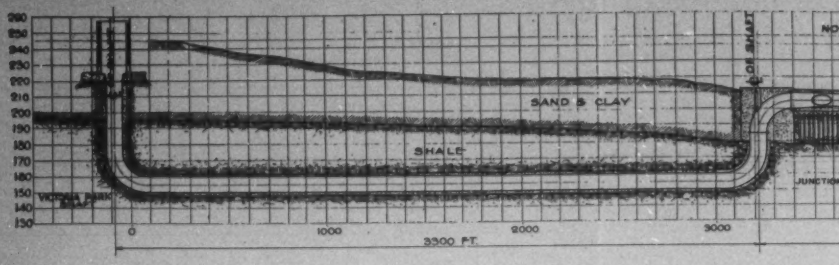
Floods in rivers or winds on lakes may set up currents capable of drifting material along the bottom of the river or lake. This may allow sand or other debris to gain access to the inlet, unless it is well above the bottom; also, part of the intake may be undermined, which action may cause breakage and failure.

The selection of the location of an intake is the first and frequently the most important step preceding its design. The topography, drainage of the adjacent lands and sewerage systems of the surrounding areas have to be studied, as well as the currents in the river or lake forming the source of supply, in order that the pollution may not be excessive and that the water may be as pure as economically and practicably obtainable.

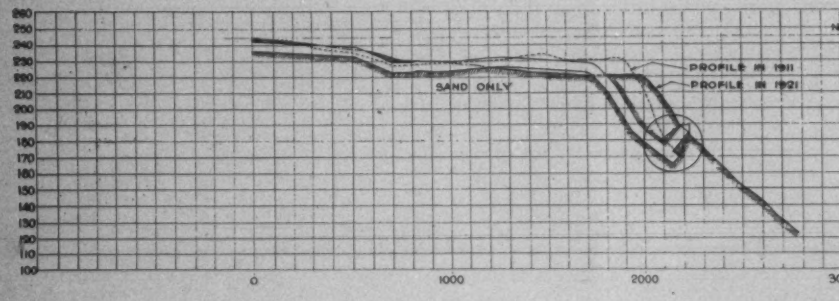
Heavy pollution usually comes from sewage and, therefore, intakes should as far as practicable be located upstream from sewer outlets. This is usually a simple matter for a river supply but in a lake it can rarely be done, although advantage can be taken of prevailing currents, distance and depth of water. Unfortunately, under favorable conditions sewage may be carried by winds and currents for long distances. This is particularly true when the temperature of the lake is much colder than that of the sewage being discharged into the lake. In such cases the pollution at times may be very high, so that its reduction by sewage treatment must be assured before the location can be safely selected for an intake.

The depth of water is an important consideration, as it reduces hazards due to ice. Depth also decreases the variation in water temperatures, a factor which is an important consideration under both summer and winter operation. In navigable waters intakes should be, if possible, off the shipping routes, in order to reduce the pollution resulting therefrom and to avoid possible interference through the dragging of anchors.

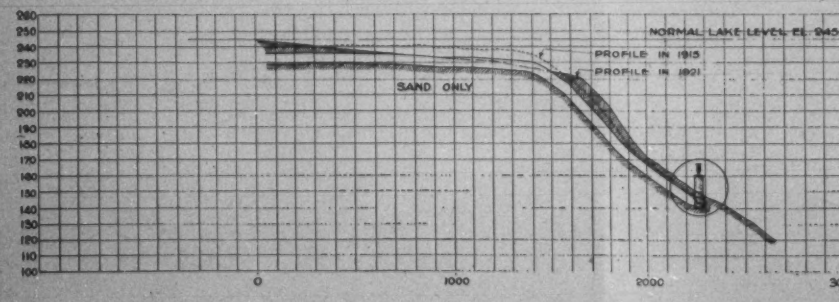
Fortunately the information and records of the conditions existing



PROFILE OF VICTORIA PA

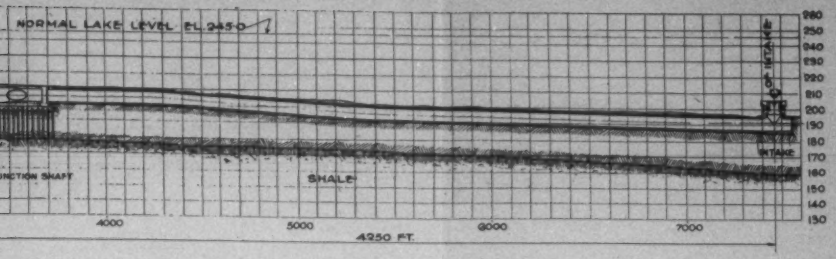


PROFILE OF ISLA

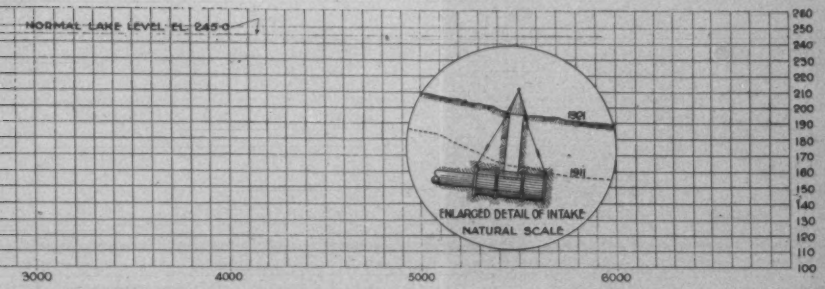


PROFILE OF ISLAND DUPLICATE INTAKE

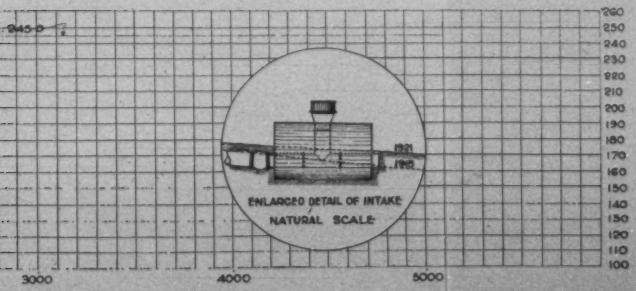
Fig 3



PARK TUNNEL & INTAKE



LAND OLD-INTAKE (EASTERLY)



KE (WESTERLY)

TORONTO WATERWORKS EXTENSIONS

PROFILE OF
INTAKE PIPES & TUNNEL

SCALE
VERT.
HORIZ. = FEET

in Lake Ontario, both as to foundation possibilities and as to the quality of the raw lake water over a long period, were available in greater detail than is usually obtainable under similar circumstances. From the standpoint of comparative freedom from physical and bacperial pollution, the Victoria Park location was easily the most favorable for a raw-water intake. It is the nearest available source of supply of suitable and presumably sustained quality and, from a topographical and structural viewpoint, equally satisfactory conditions were obtainable. Contour lines of the lake bottom were obtained and a series of borings was made. These borings were taken as far out as 9,600 ft from the shore in 54 ft of water. The borings penetrated the overburden and extended 25 to 60 ft into the underlying shale formation. A profile of the lake bottom at Victoria Park (Figure 3) indicates the typical relationship which exists at that point between the surface of the water, the earth overburden and the surface of the rock. This overburden consists for the most part of a 30-foot stratum of stiff clay with a minor admixture of gravel and firm sand, the whole constituting an entirely safe bearing medium for any heavy structure which has its footing depressed sufficiently to prevent any possibility of scour.

The underlying foundation material in the lake at Victoria Park was such that at any distance up to 6,500 ft from the shore line the construction of an intake tunnel with a reasonable depth of shore shaft offered no unusual working difficulties. The placing of the shore portion of the intake in tunnel avoids the hazards commonly encountered from ice accumulation or erosion on the fore-shore, where such intakes are laid on or immediately under the lake bottom.

The intake was constructed under two contracts. A shaft was sunk at the shore line to a depth of 110 ft below lake level and 60 ft below the top of the shale. From this shaft a tunnel was excavated through the shale, of circular section and 10 ft in diameter, with a total length of 3,300 ft (Figure 7). As soon as the shale was excavated, the rock surface was covered with a coat of gunite, thus forming an effective seal, which prevented further spalling of the shale and reduced to a minimum the seepage of water through the fissures in the shale. At the outer end of the intake tunnel, a junction shaft was constructed, forming a connection between the tunnel at eleva-

tion 143.27 and a series of three pipes, each 8 ft in diameter, placed at elevation 202.0.

The construction of the junction shaft was carried out by sinking a steel caisson through sand and clay into the rock by means of the pneumatic method. After the caisson had been sealed with concrete at the cutting edge, the air pressure was released and the balance of the shaft and the lower elbow were excavated through the rock in the open and the connection was driven through into the tunnel.

The steel caisson was fabricated and then assembled at a wharf in Toronto Bay and, when completed, was placed in the water, after which the upper section of the caisson was placed on top of the lower part of the caisson. The elbow for the junction shaft was also formed in steel and built into the caisson, the entire structure then being in a floating condition. This steel caisson is 35 ft in diameter and 34 ft high. The working chamber, which was completely encased in steel, had 7 ft 6 in. of head room above the cutting edge. Two access working shafts, each 45 in. in diameter, were constructed from the working-chamber roof through the elbow to the top of the caisson. One shaft was used for workmen and the other for handling the excavated material and concrete. Before the caisson was towed out to its final location in the lake, 115 cu yd of concrete were placed in the caisson, this concrete filling the working-chamber walls and being about one foot thick over the roof. With this concrete in place, the caisson was drawing approximately 17 ft of water, which just provided the necessary stability for towing. The caisson was towed out into the lake without any difficulty and placed in position. Some 873 cu yd of concrete were placed in the caisson in the period of two days, after which the two working shafts were extended 40 ft and air locks were fitted to the top of each shaft. Under compressed air the excavation was carried on night and day, until the cutting edge reached its final elevation of 178.0. Sand, gravel, clay and gravel with some boulders and shale were encountered in the excavation. The air pressure at the start was 15 and at the end 28 lb per sq in. After the caisson was sealed and the air pressure released, the balance of the junction shaft was carried down in the open. All rock was broken up with pneumatic paving breakers, no explosives being used at any time. The steel bulkhead was left in place until the butterfly valve was

set in position and closed, which permitted unwatering of the three-way distributor.

The three-way distributor connects to the side of the caisson at the upper elbow, having a finished inside diameter of 11 ft at this point. The other end of the distributor branches out into three openings, each 8 ft in diameter. Two of these openings have been fitted with watertight bulkheads, made of oak timber reinforced with steel. These bulkheads will be removed when additional capacity is required by laying further 8-foot diameter pipes out into the lake.

In the construction of the intake pipe proper the southerly branch of the three-way distributor was used. The distributor, weighing 235 tons, was constructed on the mainland and placed in position on top of a concrete mat, 3 ft thick, resting on timber piles.

To permit of the tunnel being unwatered at any time, an 8-foot diameter butterfly valve is located between the three-way distributor and the first length of intake pipe. The valve is constructed so as to operate by means of a hydraulic cylinder, mounted on a cast-iron bracket attached to the top of the valve.

From the distributor is laid the intake pipe, running in a south-easterly direction, consisting of 41 sections of pipe, each 100 ft long. These pipes were constructed of steel plate, lap-welded in courses approximately 7 ft wide. The end courses are ½-inch plate, the middle courses ⅜-inch plate and the balance $\frac{3}{16}$-inch plate. The two ends of each pipe are provided with a half band of 12-inch-by-¾-inch plate, bent out at right angles at the centre of each side and connected to lug angles. These horizontal extensions have holes 3 in. in diameter. The bands are attached to the upper half on one end and the lower half on the other end of the same pipe, thus forming matching connections for succeeding lengths of pipe, held together by 3-inch diameter taper steel pins in the 3-inch holes in the connection lugs. The steel fabricated pipes were conveyed to the contractor's yard in two 50-foot sections and there electrically welded into 100-foot lengths. After being placed on saddles resting on wood-bottom forms, the outside steel reinforcing was placed. The outside forms were then set and concrete was poured, forming a horse-shoe-shaped outside encasement. Each 100-foot length of pipe required 97 cu yd of concrete. The inside reinforcing bars were then placed in

position and the 2-inch gunite lining was completed on the interior. Each section of pipe (Figure 4) when completed weighed 250 tons. After being thoroughly cured the pipes were placed on a specially constructed derrick boat, taken out into the lake and lowered into position in the trench previously prepared for them.

The pipes had to be transported a distance of almost seven miles and the time of placing these pipes was governed entirely by weather conditions. The derrick boat (see Figure 5) had to be placed in exact position for lowering the pipe, after which divers were stationed at the end of the pipe on the lake bottom and, by the use of submarine telephones, gave instructions as to shifting of the pipe, in order to make the connection. Ahead of the laying of the pipe a clamshell dredge carried out the dredging work and, after this had been done and before the pipe was laid, a gravel bed was prepared on which the pipe was laid.

Precautions were taken to prevent concrete and other material from getting into the joints between the pipes and, after a sufficient time had expired, the concrete joints were poured. The 24-inch length of exposed steel plate was completely encased in concrete, all concrete being placed by the tremie method from a floating concrete plant.

At the end of the intake pipe the intake tee is located. This tee is 20 ft long, with a 2-inch gunite lining. The outer end of the tee is sealed with a steel-plate bulkhead. The 8-foot diameter outlet on top is provided with a flange, to which the circular intake is bolted. This intake structure is 20 ft in diameter and is divided into eight sections by vertical baffle plates. This furnishes eight rectangular openings, arranged in a circle, each opening being 7 ft 10 in. wide and 4 ft high. These openings are protected by vertical steel bars, 2½ in. in diameter at 15½-inch centres, extending from the top to the bottom of the openings (see Figure 6). The plates are ⅝ in. in thickness and riveted construction is used throughout. The inlet velocity for a flow of 100 mgd is 9 in. per sec.

Victoria Park Pumping Station

The pumping station at Victoria Park is an all-electric station without auxiliary power of any kind, other than a relatively small

FIG. 4.—INTAKE PIPES, 8 FEET IN DIAMETER, READY FOR LAYING.

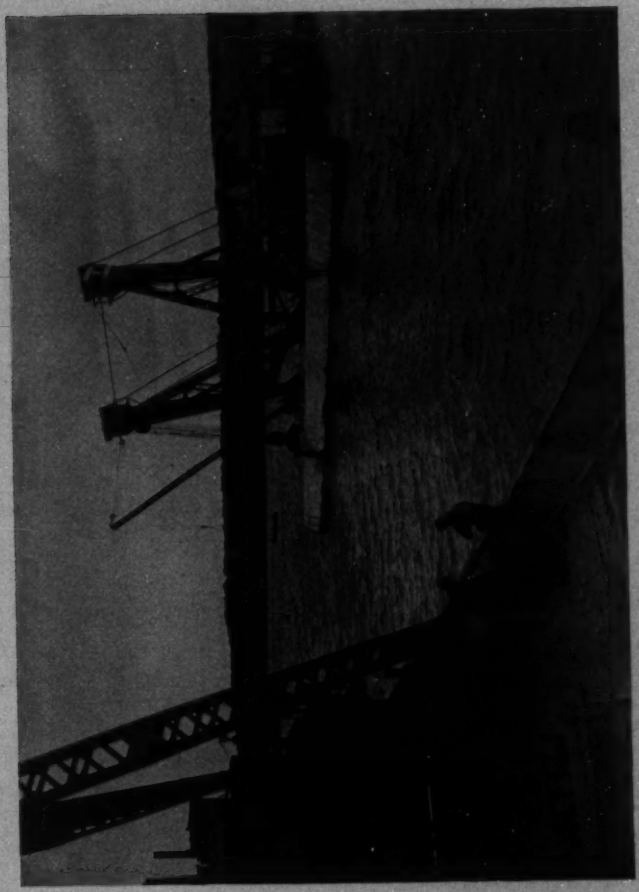
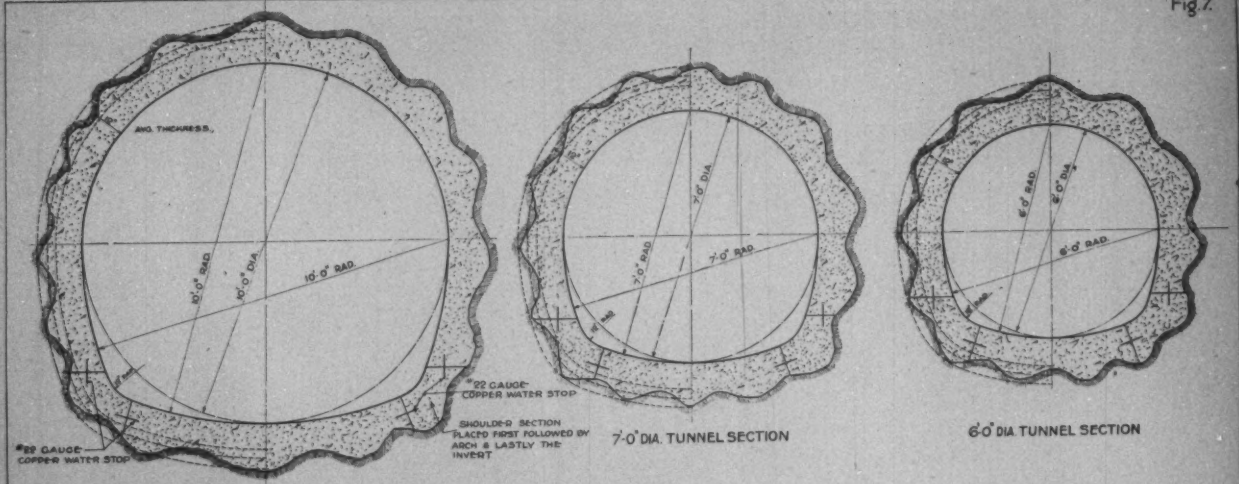


FIG. 5.—PLACING INTAKE PIPE, 8 FEET IN DIAMETER.

FIG. 6.—INLET TO INTAKE PIPE, 20 FEET IN DIAMETER.

Fig. 7.



10'-0" DIA. TUNNEL SECTION

7'-0" DIA. TUNNEL SECTION

6'-0" DIA. TUNNEL SECTION

TORONTO WATERWORKS EXTENSIONS
SECTIONS OF VARIOUS SIZED TUNNELS

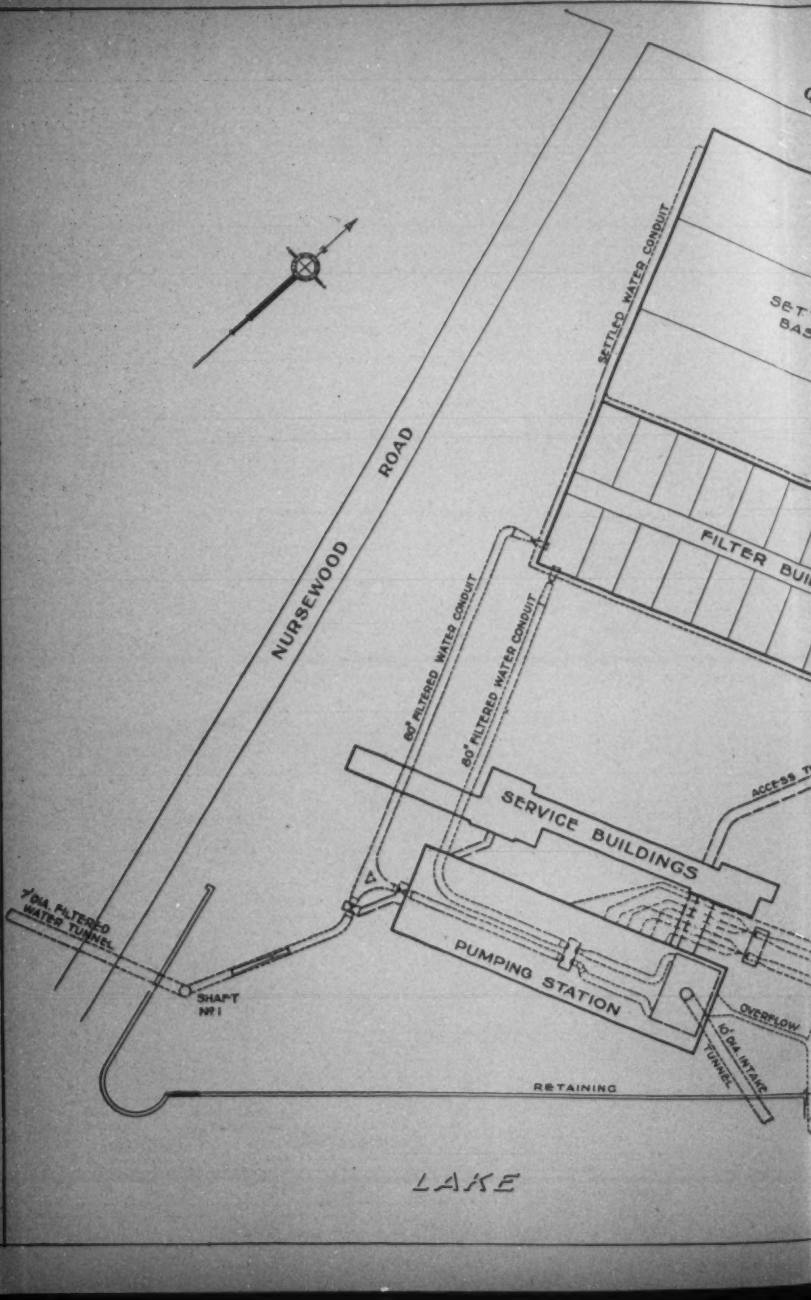
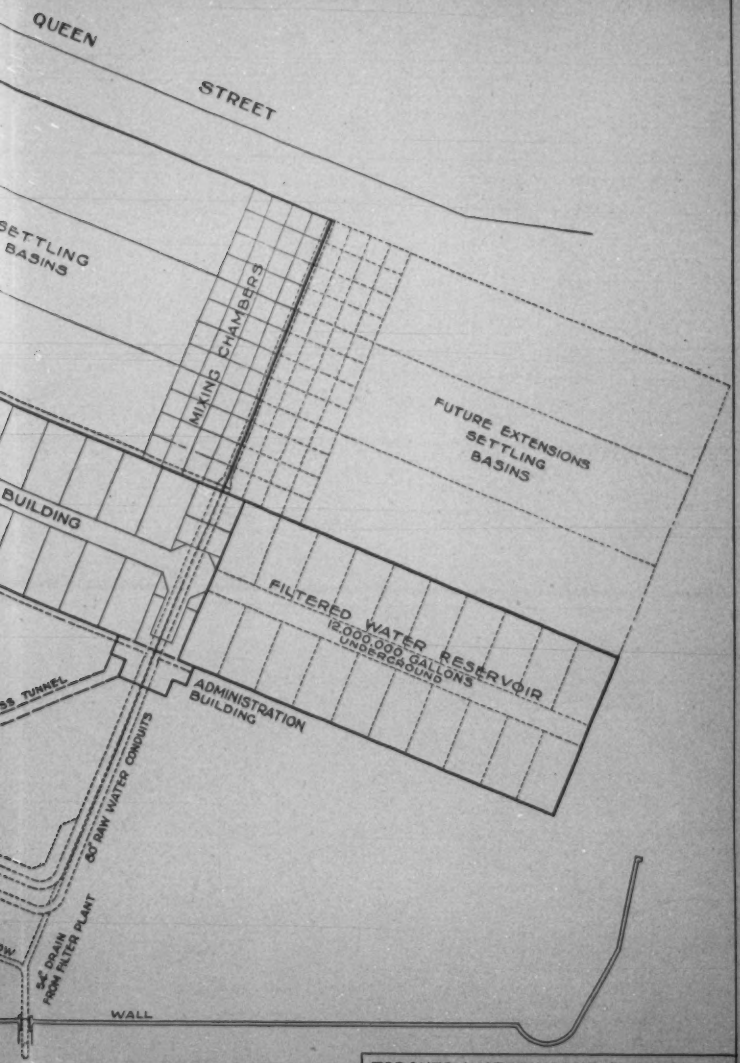

NURSEWOOD ROAD
SETTLED WATER CONDUIT
FILTER BUI
60' FILTERED WATER CONDUIT
60' FILTERED WATER CONDUIT
SERVICE BUILDINGS
7' DIA. FILTERED WATER TUNNEL
SHAFT Nº1
PUMPING STATION
OVERFLOW
10' DIA. INTAKE TUNNEL
RETAINING
LAKE

Fig 8



ONTARIO

TORONTO WATERWORKS EXTENSIONS

VICTORIA PARK WATER PURIFICATION PLANT

LAYOUT

SCALE

supply obtained from storage batteries, which are available at all times for the automatic operation of switching equipment and for certain emergency lights, selsyn motor and synchronous clock circuits. The pumping station contains the low-lift pumps, which pump raw water to the filter plant, and the high-lift pumps, which pump filtered water into the distribution system. Also included in the station are the wash-water pumps.

The pumping-station structure is 295 ft in length by 84 ft in width and is divided into four parts, the intake and screen section, low-lift pump section, high-lift pump section and administrative and control section. In addition to the pumping station proper, there are several valve and meter chambers with interconnecting galleries and a very substantial group of service buildings, comprising the chemical plant, heating plant, transformer station, workshops and stores, the location and extent of which are evident from a study of Figure 8.

The intake and screen section of the pumping station is built directly over the intake shore shaft and contains four, and ultimately eight, mechanically operated travelling screens, through which the incoming water passes to two 84-inch suction headers. Each of the screens is contained in a separate compartment, which can be isolated by electrically operated sluice gates. In the construction of the screen section provision is made for a surge overflow duct, which will adequately handle any surge that may be caused by sudden stoppage of the raw-water pumps, due to failure of the power supply.

The pumping equipment installed is of interest due to the high efficiencies guaranteed and obtained. The pumps were manufactured by the Dominion Engineering Works, Limited, Montreal, Quebec, who made models in the testing laboratory for each size of unit and used the results obtained as a basis for the design of the full-sized pump, which proved very satisfactory.

There are eleven pumps in all—four supplying raw water from the intake well to the settling basins, four for delivering filtered water to the distribution system and three for supplying filtered water for washing the filters. Each pump is connected to its own motor with 25-cycle, 3-phase, 2,200-volt current.

In testing the pumps mercury columns were used for all pressure measurements, even for heads of 270 ft—in which case the mercury

column was nearly 25 ft high. The accuracy of the measurements was greatly improved in some of the pumps by connecting the suction and discharge pipes to the mercury column in such a way that the latter read the net pressure rise produced by the pump and automatically allowed for difference of elevation of the connections. In making the tests all instrument readings were photographed simultaneously and the results obtained represent a high degree of precision.

The guaranteed overall efficiencies and the actual efficiencies obtained for the various units are shown in the following table:—

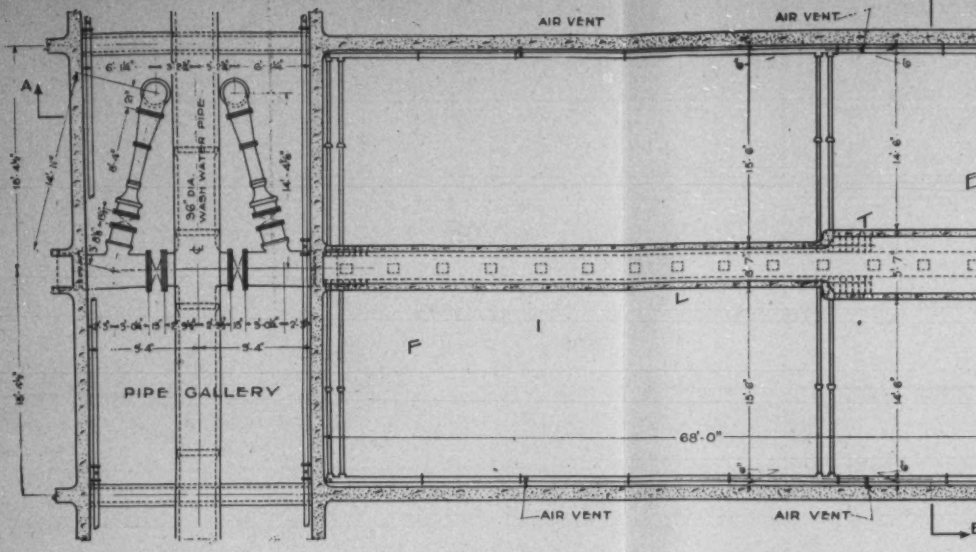
Item no.	Description	Number of units	Mgd	Discharge pressure (ft)	Suction pressure (ft)	Total head (ft)	Overall efficiency (%) Guaranteed	Obtain
1	Raw Water	1	50.0	73	9 (Lift)	82	86.3	86.7
2	" "	1	40.0	73	9 "	82	86.0	88.5
3	" "	1	25.0	73	9 "	82	85.1	87.9
4	" "	1	20.0	73	9 "	82	84.5	86.0
5	Filtered Water	2	25.0	306	36 (Pressure)	270	86.0	87.6-8
6	" "	2	5.0	232	36 "	196	81.4	81.9-8
7	Wash Water	1	10.0	90	36 "	54	80.5	81.5
8	" "	1	7.5	90	36 "	54	79.2	80.2
9	" "	1	5.0	90	36 "	54	77.9	79.2

All pumps exceeded the guaranteed efficiencies. Deductions in the contract price were provided as liquidated damages for each 1% less than the guaranteed efficiency, such deductions varying from $180.00 in the case of the smallest wash-water pump to $4,450.00 for the 25-mgd filtered-water pumps.

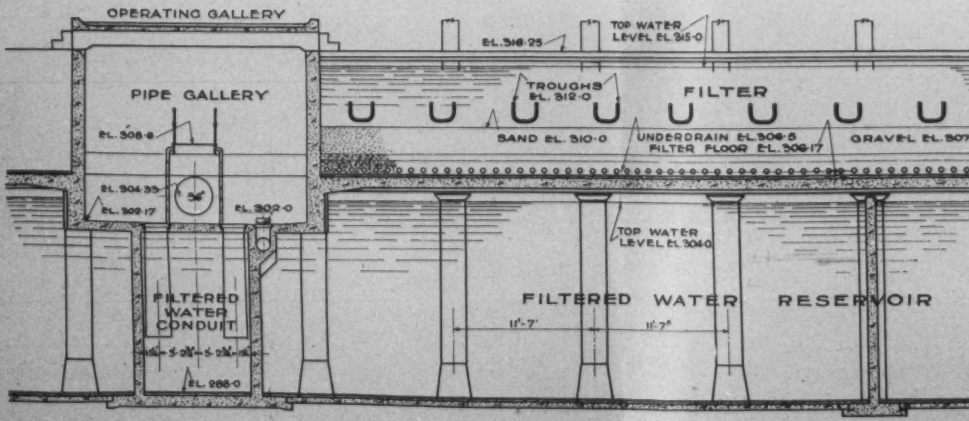
Victoria Park Water Purification Plant

The water purification plant and pumping station at Victoria Park are the major units in the water-works extension scheme. The general layout of the works at Victoria Park is shown in Figure 8. The general design of the purification plant was influenced to a large extent by the shape and topography of the site.

The water purification plant contains a filtered-water reservoir, having a capacity of 12 mil gal, over which are constructed the filters,

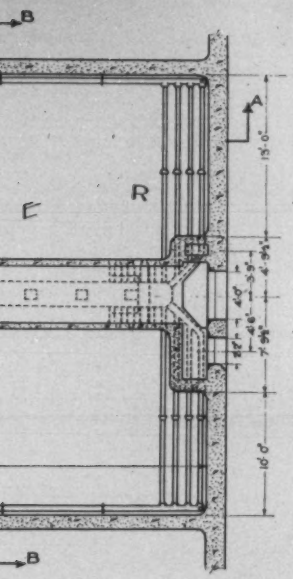


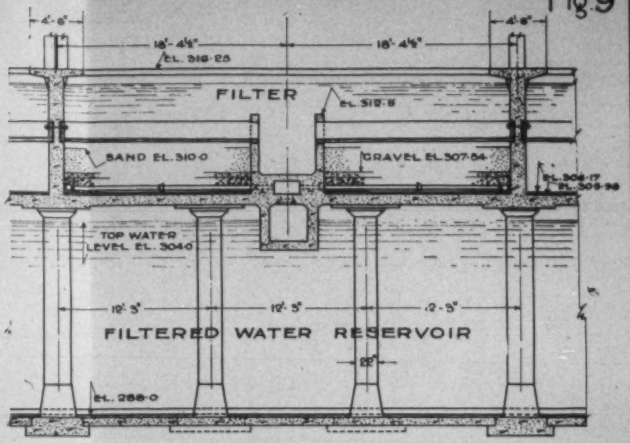
PLAN



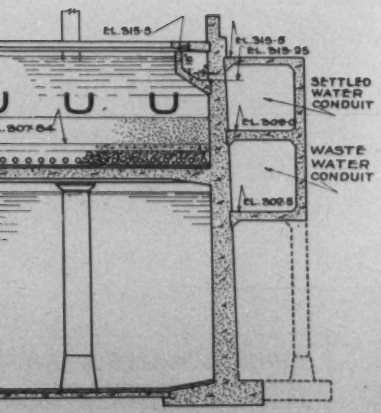
SECTION A-A

Fig. 9





SECTION B-B



TORONTO WATERWORKS EXTENSIONS

VICTORIA PARK
WATER PURIFICATION PLANT
TYPICAL FILTER

SCALE
FEET

pipe galleries, concourse and chemical room. For the present, 20 filters comprising the western half of the ultimate plant have been completed, together with the administration building, the central concourse and chemical section. Above the concourse and chemical section the wash-water tanks are placed.

The portion of the reservoir extending to the east of the main concourse forms the foundation for an additional 20 filters, which will give the plant an ultimate capacity of 200 mgd at the standard rate of filtration of 105 mgd per acre. As the roof of the reservoir forms the floor of the filters and pipe gallery, all wall and floor castings, filter-effluent conduit, concrete Venturi meter, etc., required for the future filters have been constructed where these are located within the reservoir.

The mixing chambers and settling basins are located to the north of the reservoir and filters.

The filters are arranged on either side of a single filter-operating gallery, underneath which is the pipe gallery. The pipe gallery contains only the main wash-water and the filter-effluent piping, the settled-water influent and the wash-water waste conduits being at the back of the filters.

Each filter (Figure 9) is 68 ft long and 35 ft 7 in. wide and has a net filter area of 2,103 sq ft, which at the standard rating of 105 mgd per acre gives each unit a capacity of 5 mgd.

These filter units are unusually large and particular attention has been given to the design of the wash-water system, in order to secure an even distribution of wash water and therefore a uniform rate of back-wash throughout the filter area.

The underdrain system of one filter unit consists of a concrete conduit, 3 ft square in cross-section, constructed integrally with and underneath the filter floor and along its centre line. The wash water enters this conduit from the 36-inch cast-iron pipe in the filter pipe gallery through a 30-inch hydraulically controlled gate valve and then passes upward through 14 rectangular ports into a rectangular distribution manifold, constructed in concrete. These ports are of sizes and spacing designed to compensate for the varying conditions of flow, such as the friction loss, reduction in velocity and increase in pressure along the length of the conduit.

From the manifold the wash water is distributed through the underdrain lateral pipes, which were designed to secure, as far as practical, equal flow through each orifice. The lateral pipes are of cast iron, 4 in. in diameter at the inlet end and tapering to 2½ in., and are spaced 12 in. apart. The orifices are on the underside and consist of brass nozzles of ¾-inch bore, also spaced 12 in. apart, with the result that there is one orifice per square foot of filter area. The outer ends of the underdrain laterals are interconnected by a cast-iron manifold pipe, extending along the side walls of the filter, the purpose of which is to offer a further equalizing effect, should the pressure in one area be greater or less than in another.

The filter bed consists of graded gravel to a depth of 18 in., over which is a blinding layer of coarse sand 2 in. thick. Over this, filter sand to a depth of 26 in. was placed. The filter sand has an effective size of 0.55 millimeters and a uniformity coefficient of 1.5.

The wash-water troughs, made of reinforced concrete (Figures 9 and 10), lead to a central main drain in each filter. The piping in the main gallery is of cast iron throughout and all of the control valves are hydraulically operated. The complete control of the operation of each filter, together with the recording apparatus, is governed from an operating table situated on the operating floor—one table to each filter. The operating gallery has a terrazzo and marble floor, with skylights running throughout the length of the building. In order to keep down the cost of heating the building, each side of the operating gallery has been enclosed with glass windows. The outside walls of the building are of gray stock brick with stone trimmings. The flat roof over the filters is of reinforced concrete and is covered with cork insulation, felt and gravel roofing.

A feature worth special mention is the provision for chlorinating and dechlorinating the filtered water. The effluent pipes from each filter discharge into a concrete filtered-water conduit in the reservoir, in which a meter of rectangular section is constructed. After passing through this meter, the filtered water is dispersed within a walled area at the centre of the reservoir, into which the chlorine solution is diffused. To reach the reservoir outlet the chlorinated water must travel a definite path by reason of the concrete baffle wall, the purpose of which is to ensure a minimum contact period of chlorine and water

FIG. 10.—CONCRETE WASH-WATER TROUGHS IN FILTER UNIT.

when superchlorination is practised. Also, the path of the water is arranged to permit of dechlorination prior to the water's leaving the reservoir.

The purpose of the Venturi meter in the filtered-water conduit is to afford a continuous indication of the total rate of filtration, for the guidance of the chemical operators.

Chlorine and sulphur dioxide are stored in one-ton cylinders in the chemical storage room. The solution-feed machines and evaporators are located in the chemical machine room, directly over the reservoir and within a few feet of the point of application of the chemical. The chemical storage room is equipped with an overhead water fine-spray system, which can be controlled from outside the room in the event of a major gas leak.

The filter rate controllers are of the double butterfly-valve type and are connected to a central master control, which is actuated either by a float on the water level in the reservoir or manually. Under normal working conditions, the maximum rate is set on the manual control but, when the water level in the reservoir is within one foot of the overflow, the float control will regulate the rate according to the distance the water level is below the overflow.

The whole operation of the filter plant conforms closely to the standard practice used in mechanical filtration. The water is treated with filter alum, which is supplied from dry-feed machines placed in a separate building. Provision has also been made for treating the water with activated carbon, should this be found necessary.

One of the main features connected with the plant is the mixing and coagulating tanks. This type of mixing tank was developed by the late William Gore and is usually referred to as the "Gore mixing tank." Previous to the construction of the Ottawa water purification plant two trial filters were erected there, chiefly with the object of developing better methods of coagulation. The results obtained from the operation of this plant are fully described in a paper entitled "The Trial Filtration Plant, Ottawa, Canada" by George G. Nasmith. The method as now worked out has proved exceptionally efficient and for several years has been in operation at Toronto, Ottawa, Calgary, Belleville and St. Thomas. For the maximum rate of flow the mixing tanks have a capacity for 40 minutes' treatment and the settling

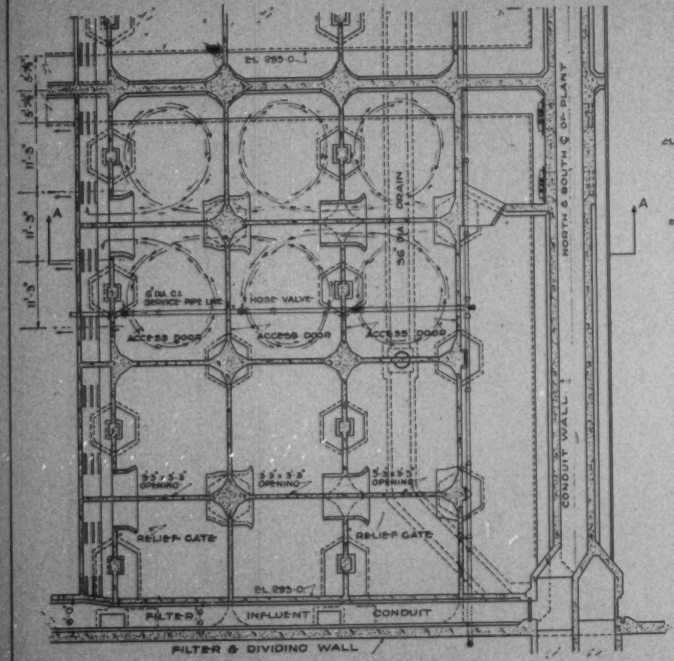
tanks for 2 hours and 50 minutes. The combined mixing and settling tanks are three in number, each 389 ft 3 in. in length, 90 ft in width and 23 ft 8½ in. in depth. Each mixing chamber is 90 ft in width and 73 ft in length, divided into 12 separate compartments. This part of the plant was designed to produce a very gentle stirring action and distribute the flocculated water into the settling tanks without breaking up the floc, which is extremely fragile. Short-circuiting was reduced to a minimum by dividing the process into several stages and by the special design of the passages. The raw water, after treatment with the necessary chemicals, is brought to the settling tanks by a concrete conduit running along the easterly wall. From this conduit the water enters the mixing chambers and the direction of flow from one compartment to another changes, until the water finally reaches the settling tank as shown in Figure 11. The coagulation obtained in these chambers is most effective and the total loss of head in passing through the various compartments is about four inches at normal capacity.

The administration building, situated in the centre of the final development, contains, besides the administrative offices, a fully equipped laboratory with all the necessary apparatus for controlling and directing the water purification operations.

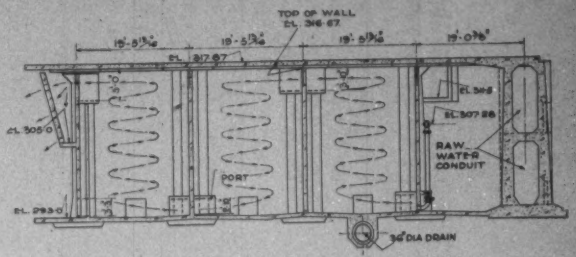
St. Clair Reservoir

The first actual work to be placed under construction and put in service was the St. Clair reservoir to take care of District No. 2. This reservoir, with a capacity of 50 mil gal, is built of reinforced concrete throughout, the roof being supported on columns. The flat-slab roof has the 3-way system of reinforcing and is 10 in. in thickness. The earth fill to a depth of 2 ft has been sodded over and a most serviceable park for the use of the citizens is available at all times. Tennis courts and other outdoor recreations are in full swing, particularly in the summer months. The reservoir is divided into two compartments of equal capacity. Figure 12 shows typical cross-sections through the outer wall, dividing wall and columns. There are 830 columns supporting the roof. The columns are spaced at 21-foot 6-inch centres and the reservoir has a water depth of 23 ft. The volume of concrete placed amounted to 42,452 cu yd.

Fig II



PLAN

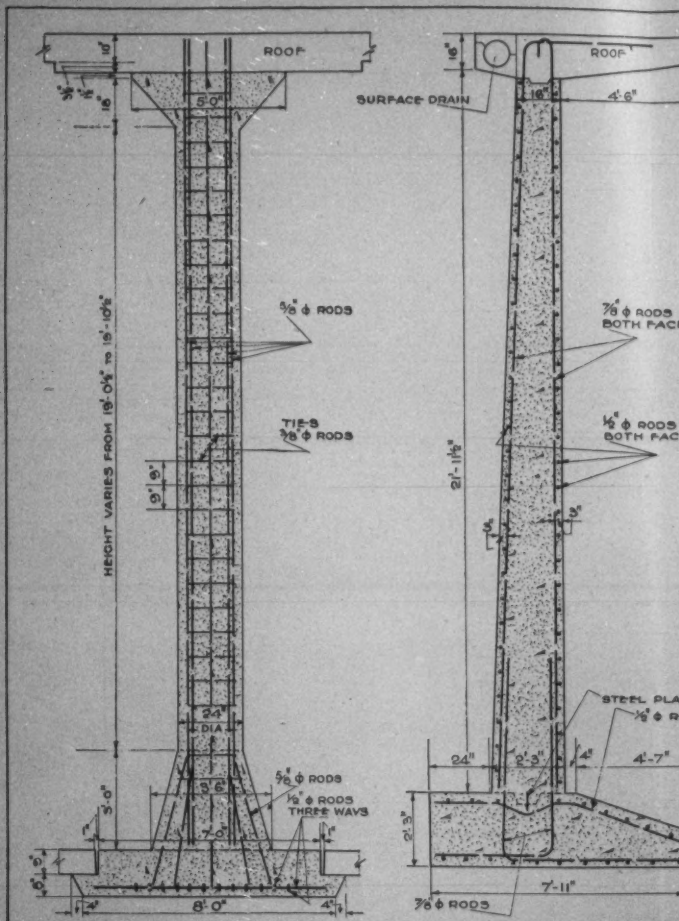


SECTION A-A

TORONTO WATERWORKS EXTENSIONS

MIXING CHAMBERS

SCALE

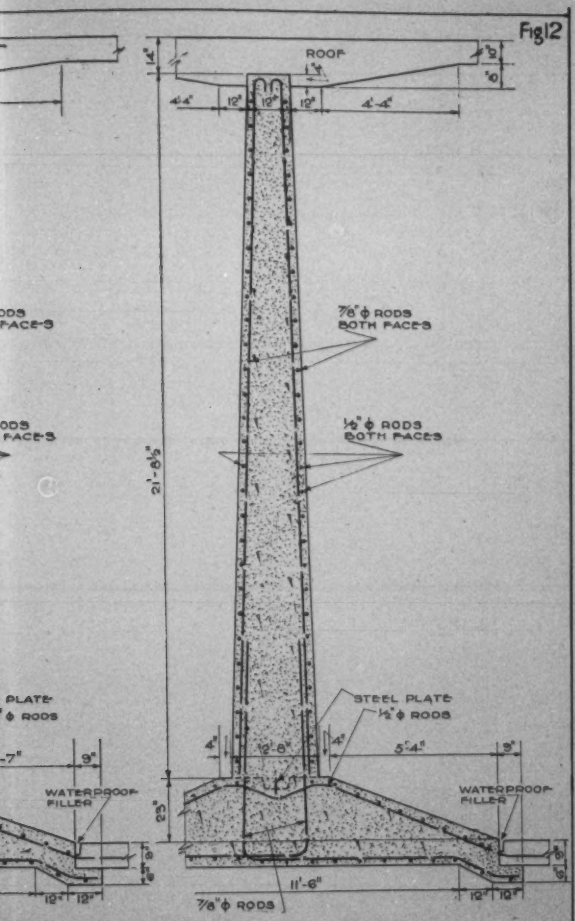


DETAIL OF COLUMN UNIT

SECTION OF OUTER

TORONTO WATERWORKS
ST. CLAIR RESE

Fig 12



R WALL

SECTION OF PARTITION WALL

RKS EXTENSIONS
SERVOIR.

On top of the concrete floor of the reservoir a waterproof membrane was placed, consisting of a layer of asphalt-saturated asbestos, mopped with a coating of asphalt waterproofing cement. Thirty pounds of such cement were used for each 100 sq ft and, while still hot, a layer of asphalt-saturated fabric was embedded in it. The surface of this saturated fabric was again mopped with a coating of waterproofing cement and, while still hot, a layer of asbestos felt, laid at right angles to the fabric with joints lapped 3 in., was embedded in it. Over the surface of this felt a coating of waterproofing cement was placed. Once this had been completed and allowed to set thoroughly, a two-inch layer of concrete was placed over the entire reservoir floor.

Under the contract a leakage test was carried out, extending over a period of five days. The permissible invisible leakage during the test was not to exceed 60 Imp. gal per min. The total floor and wall area of the reservoir subject to leakage is about 174,000 sq ft and the test showed that the total leakage during 120 hours was 6,160 gal, or somewhat less than one Imperial gallon per minute.

Chemical Treatment

The chemical plant is designed to contain a reasonable storage of alum, based upon an ultimate capacity of 200 mgd. Alum is delivered to the plant in bags by trucks and handled by pneumatic conveying equipment into the storage bins. From the storage bins it is drawn by gravity into weigh hoppers, furnished in connection with the dry-feed chemical machines of the gravimetric type. Two such machines are installed at present for alum and a third machine may be used for activated carbon or such other chemicals as may be required in the future. From the solution chambers of the chemical machines the solution flows by gravity and is applied to the incoming raw water at the intake well.

Each of the two storage bins has a capacity for 140 tons of alum. The dosage of alum applied to the raw water averages 0.5 grains per gal and does not exceed 1.5 grains per gal.

Tunnels

From Victoria Park a concrete-lined filtered-water supply tunnel has been constructed to the John Street pumping station and continues westward to a pumping station to be erected at Parkdale. The raw-water tunnel is 10 ft in diameter, whereas the tunnel from Victoria Park to John Street is 7 ft in diameter and from there to Parkdale 6 ft in diameter. At the John Street and Parkdale pumping stations surge tanks are provided.

In all, eight shafts were sunk over the entire length of 49,662 ft of filtered-water tunnel. A detailed section of each size of tunnel is shown on Figure 7. After the contract was awarded, the section of the tunnel was changed to suit the method adopted in construction by the contractor, from a true circle to a horse-shoe shape, so as to permit of easier transportation facilities. This increased the area of cross-section by approximately 5% without making any change in the contract sum.

The shafts were lined down to the shale level with steel sheet-piling and, in the shale portion of each shaft, the surface was treated with gunite soon after being exposed, in order to reduce to a minimum the spalling of the rock. Headings were driven from each shaft and all excavation was taken out in one-yard dump cars on a 24-inch gauge track with 25-pound rail, all the hauling being done by ponies. The track was of the one-way type with passing switches. The excavated material was hauled to the surface at each shaft by means of a cage, dumped into a 50-cu yd hopper and taken away by trucks to a series of disposal areas provided by the city, in most cases in close proximity to the shafts. The line of tunnel being along the water-front, suitable disposal areas in close proximity to the shafts were secured in connection with the reclaiming of land for harbor development. Generally the shafts were 18 ft in diameter in the overburden, where they were lined with steel sheet-piling, and 13 ft in diameter in the rock. The steel sheet-piling was driven by a steam hammer and braced internally with angle rings. The headings were driven 2 ft larger than the finished diameter of the tunnel. The tunnel lining throughout consisted of concrete with a minimum compressive strength of 2,500 lb per sq in. over a 28-day period. All of the concrete was

mixed in transit, then deposited into a 4-cu yd hopper at the top of the shaft and placed just below ground level. One-cubic-yard cars were placed on the cage and filled from the hopper, lowered in the cage and hauled along the tunnel to the Ransome pneumatic placing machine, which had a capacity of 14 cu ft for each shot. The concrete was dumped into a box and then placed on the belt conveyor, which carried it to the hopper of the pneumatic placer. The concrete was then shot by air into the forms. Steel forms were used throughout and a maximum length of 100 ft was poured at one operation.

The rock shale through which the tunnel was driven disintegrated quickly when exposed to the air. This difficulty was overcome by guniting the walls of the tunnel before the concrete was placed. The gunite was generally ¾ in. thick and the operation was commenced as soon as possible after the excavated material had been taken out. The gunite successfully prevented further disintegration of the rock and held the surface intact over a period of several months, until the final concrete was placed. At each shaft there was erected a pump having a capacity of 130 gal per min, to take care of the leakage into the tunnel through fissures in the rock, and also an electrically driven air compressor for operating the rock-drilling equipment, a double-drum mine hoist, electrically operated for hoisting the equipment, and an electrically driven reversible blower of 2,000-cu ft capacity for ventilating purposes. These fans developed a maximum pressure of 3½ lb per sq in. As soon as the blasting had taken place in the heading, the fans, which were supplying fresh air to the heading, were reversed and used to exhaust the powder smoke from the heading. After running in this way for 30 to 60 minutes the fans were again reversed for pumping fresh air to the underground workings. The air line for the drilling equipment was 4 in. in diameter and for the ventilating air a 10-inch galvanized pipe was used throughout.

Power Supply

It will be noted that there is no standby power at the Victoria Park pumping station. Electric power is secured from two entirely independent sources of supply, through two electric substations with the power cables laid underground. Since the pumping station was

placed in operation almost six years ago, only two power failures have occurred, one of seven minutes' and the other of three minutes' duration.

In the event of a power failure of long duration, there are ample steam auxiliary supplies available at the John Street pumping station. The St. Clair and Rosehill reservoirs have a combined capacity of 88 mil gal and the Island and Victoria Park reservoirs have capacities of 7 and 12 mil gal, respectively. Should, for any almost inconceivable reason, all filters be out of commission, then unfiltered chlorinated water can be sent from both the Island and Victoria Park plants to the John Street pumping station.

Owing to the combined storage capacity of filtered water in the various reservoirs, the duplicate source of electric power supply and the ample steam standby at the Island, John Street and high-level pumping stations, it was considered unnecessary to provide steam or any other type of standby at the Victoria Park pumping station.

Operating Results

A general statement of the operating results of the three water purification plants may be of interest. As previously stated the three plants are:—

1. Slow sand plant placed in operation in 1912 with a capacity of 36 mgd.
2. Drifting sand plant placed in operation in 1918 with a capacity of 60 mgd.
3. Rapid sand plant placed in operation in 1941 with a capacity of 100 mgd.

Due largely to pasteurization of the milk supply and the filtration and chlorination of the water supply, the typhoid mortality rate has been reduced from 43 per 100,000 in 1910 to not a single death in 1945 or so far in 1946. The typhoid-fever mortality rate reached its highest peak in 1890 with 93.1 per 100,000 persons. Chlorination of the water supply commenced in 1910, Toronto being the first municipality in Canada to adopt the same.

The slow sand plant gives a high bacterial removal and reduces greatly the taste-forming substances. The plant in every respect is highly efficient and the effluent is produced at less cost than with mechanical filtration. Heavily polluted water, containing taste-forming substances, is more efficiently treated with the slow sand filters and very rarely are tastes and odors found in the chlorinated effluent.

The drifting sand plant proved difficult to operate under severe storm conditions when high turbidities existed. The raw coagulated water is sent directly to the filters without any settling period beforehand. Under such conditions the slow sand plant operated with fewer difficulties. Under normal operating conditions the drifting sand plant gives excellent results, maintaining a high rate of filtration with a very low loss of head. The filters have operated for 21 days without being backwashed and, under periods of heavy consumption, the 60-mgd plant has operated for several hours at a time at a rate of 175 mgd without any operating difficulties.

The rapid sand plant has given excellent results. Like the other plants the main operating difficulties have been with taste and odor. The means adopted to overcome taste and odor troubles have been fully covered in various papers prepared by Norman J. Howard, the Director of the Toronto Water Purification Plants.

Wide variations take place in the condition of the raw water at the three intakes. With a filtering capacity considerably in excess of the consumption, it is possible by laboratory control to draw water from whichever intakes indicate the purest water. The wind conditions are the chief causes of change in raw-water conditions and, with laboratory control and observations of the wind direction, a reasonably accurate determination can be quickly ascertained of the nature of the raw water at each of the intakes. With most of the sewage from the city being discharged, practically without treatment, about midway between the Island intakes and the Victoria Park intake, it follows that with an easterly wind the Victoria Park intake gives purer water than the Island intakes, due to the sewage field being driven towards the Island intakes. For a large portion of the time the water at Victoria Park intake is of much better quality than at the Island intakes, due to the favorable location of the intake. So long as the filtering capacity is in excess of the demand this flexibility in operation can be used to advantage.

As a tribute to the late R. C. Harris, for 33 years Commissioner of Works for the city of Toronto, the complete works at Victoria Park have been named "The R. C. Harris Water Purification and Pumping Plant."

Discussion

Francis F. Longley (East Orange, N. J.). Mr. President, I listened with the greatest interest in the world to Mr. Storrie's paper, hoping up to the last minute that he would say what he did in the last few minutes to correct—or to amplify, let me say—an impression that I think he gave in describing his slide. As he was describing the relative positions of the intakes and of the sewage outlets at Toronto from the first slide, I had the impression that the listeners did not understand that the nearer proximity of Victoria Park to the sewage outlet really did not make any difference, because of the direction of the current in the lake, and I was hoping for some explanation of that, which Mr. Storrie did give slightly in the last few minutes of his talk. I wondered if he would be willing to amplify that a little bit, so as to make it quite clear that Victoria Park is immensely superior in its location to the old location off of Toronto Island.

William Storrie. From every point of view there is no comparison between the Island intakes and that established at Victoria Park. The physical conditions that exist, the nature of the bottom, the nature of the ground through which we had to construct that tunnel, the nature of the lake bottom where we constructed the intake, the small gathering area on the mainland behind it, and the fact that the dominant tendency there is for an easterly wind, causing an almost continuous drift toward Centre Island from the sewage outfall, make Victoria Park without doubt a site that certainly is very desirable. The fact of the sewage outfall being midway between the two sets of intakes has very little bearing on it.

This question of wind currents is exceedingly interesting and it is a question on which I find a tremendous difference of opinion. You will get a very calm day in Toronto and you will find that a sewage field develops in front of the sewage outfall; and then you will get an easterly wind which drives that field toward the Centre Island intakes. By observation, the operators at Victoria Park and at the Island can pretty well tell when the wind changes and, by the velocity of it, just when they are going to get sewage pollution. When that happens they change the operation of that plant entirely. But

for at least 75% of the time the bulk of the drift seems to be toward the Island intakes and, while there may be heavy bacterial counts for days on end, if you will compare those with counts taken at Victoria Park at the same time you will find that the latter are extremely small. The Victoria Park intake is away from all possibility of summer traffic or any highway contamination of that sort.

To get back to the question of the currents, some years ago we put out a number of floats at the mouth of the Niagara River and endeavored to trace those from day to day by a motor-boat going out from Toronto. A lot of them were lost. But it was exceedingly interesting to see the development and the course taken by those floats. We found those surface floats and the sub-surface floats going in opposite directions. That was a common experience. The sewage, being warm compared with the lake water, has a tendency to stick to the top. And it reaches the Island intakes with comparatively little dilution, despite the four miles traveled. So that from every point of view there is no comparison between the location of the intakes on the Island and that of the new system at Victoria Park.

CHARLES G. RICHARDSON (Providence, R. I.). I would like to ask Mr. Storrie about those spiral flocculation tanks which seem to be operated so efficiently in Canada and yet, as far as I know, have not been used in the United States. If I recall correctly, Mr. Storrie, the tanks at Ottawa are circular and those in Toronto, I judge from the drawing, are rectangular or square. Is there any difference in the efficiency of those two designs?

WILLIAM STORRIE. None of the tanks are square; they are all circular or rectangular.

CHARLES G. RICHARDSON. I was mistaken.

WILLIAM W. BRUSH (New York, N. Y.). I would like to ask Mr. Storrie about a tunnel which is run along the shore front, taking the water from the various plants, as to the question of pollution. Is there any danger of polluting that water as it passes through the tunnel?

WILLIAM STORRIE. The tunnel is very much like the intake tunnel and it is down for the most part in shale. In fact, it is all in shale. There is a minimum cover of 25 ft on top of the tunnel, consisting of shale. Before we constructed it, we put down a series of borings

all along the waterfront and we got a reasonably level line all the way through. At one point we did run out of the shale into what turned out to be the bed of an old river that we knew nothing about, and we had to reverse our steps about a thousand feet and start to go down and come up again. The tunnel, when it was constructed through the shale, showed a tendency to spall and all that surface was gunited. It is impossible for pollution to get into the tunnel. Due to the head from the reservoir at Victoria Park, the pressure on the tunnel is outward.

E. Sherman Chase (Boston, Mass.). I would like to inquire from Mr. Storrie as to whether or not there have been any drifting sand filters installed in Toronto; and what were the reasons that they were not adopted with the present, most recent, installation?

William Storrie. That is a very good question and it is a somewhat delicate one, as you must realize. The drifting sand filter is undoubtedly a success; it was invented by my partner, the late Mr. Gore, and Toronto would put it in today if we were left alone. But everywhere we went we were met with the observation, "You are under no competition with the drifting sand filter." I simply say we are not going to install it anywhere in order to escape that criticism that was continually being thrown at us. So far as the plant itself is concerned, it has done magnificent work. There is one thing that would be a decided advantage and that is, if under heavy turbidity conditions there was some pre-settling period. That is also true of the slow sand filter plant. In very heavy turbidity conditions, a pre-settling plant at the Island filters, I think, would overcome a lot of the difficulties.

Linn H. Enslow (New York, N. Y.). I do not remember that Mr. Storrie called attention to the fact that his waters at Ottawa, for which this mixing was originally designed, were as diametrically opposite to the quality of the water at Toronto as could well be imagined. It is very interesting that the same design has worked so well under both conditions. I would like to ask Mr. Storrie, what provision is made for the initial rapid mix? The mix that he described is really a flocculation rather than a mixing, as I get it. There must be some rapid mix there ahead of the flocculating mix of a spiral motion.

The other question, Mr. Storrie, is: Do you have to cut out sections of that mixing chamber as you cut out filters, in order to maintain proper velocities for the spiral motion? That is to say, my experience with that type of design in Panama was that I had to cut out sections in order to maintain certain velocity zones—in order to keep those spiral-motion units efficient.

WILLIAM STORRIE. The settling tanks are three in number and are attached to each of the mixing chambers, divided into two compartments. If you wanted to do anything to the mixing chamber, you would have to take out one whole settling tank and the twelve mixing chambers attached to it. We have not found any difficulty in the flocculation in the mixing chambers, due to the varying velocities within the limits of the plant. That has not given us the slightest trouble. The coagulant, the alum, is applied just on the discharge side of the pumps and there is every indication that it is quite thoroughly mixed by the different twists and turns back in the pipe line, and particularly in the inlet chamber, just before going into the mixing tank proper. There is every evidence that there is a thorough mixing before the water gets into that spiral action in the mixing chamber.

ARTHUR L. SHAW (Boston, Mass.). I was very much interested in the pump specifications and in the fact that there was a penalty for efficiencies below those guaranteed. It would be of interest, I am sure, to learn whether there was an incentive set up so that a bonus would be paid for any efficiencies over those guaranteed.

WILLIAM STORRIE. I don't know what the law is here but the law in Canada is that you can't collect a penalty unless you offer a bonus. You can't collect a penalty for low efficiencies, unless you offer a bonus for anything over guaranteed efficiencies. I don't know whether it was a Scotchman or not who said that it is not a penalty, it is simply liquidated damages. In the specifications the word "penalty" is not used but "liquidated damages" is the term employed.

REFORESTATION ON THE QUABBIN RESERVOIR PROJECT

BY RUSSELL SNOW*

[*Read September 19, 1946.*]

BY AN act of the Massachusetts Legislature a bill was passed in 1926, providing for the extension of the water-supply system of the Metropolitan District, which includes Boston and its surrounding communities. A special commission was established, which was known as the Metropolitan District Water Supply Commission, consisting of a Chairman, who was the then Chairman of the existing Metropolitan District Commission, and two Associate Commissioners, appointed by the Governor and Council.

This Commission appointed a Chief Engineer, who organized the necessary engineering force to conduct the work required for the construction of the Quabbin Reservoir and the Aqueduct which would carry the water to the present Wachusett Reservoir in Clinton.

As the result of previous studies and investigations of water-supply resources throughout the State of Massachusetts, the site selected for the new reservoir was located in the Swift River valley and included all of the towns of Enfield, Greenwich, Prescott and Dana, and portions of the surrounding towns of Ware, Belchertown, Pelham, Shutesbury, New Salem, Wendell, Orange, Petersham, Barre and Hardwick (see Figure 1). The reservoir was named "Quabbin" after a locally famous Indian chief, for whom a mountain and lake in the vicinity had been named.

This project was started in the latter part of 1926 and during the following fifteen years a total of approximately 83,500 acres of land was acquired in the valley. An earth dike with a concrete core wall, known as Quabbin Dike, 2,140 ft long, 135 ft high and containing 2,500,000 cu yd of earth fill above the original surface, was constructed by the hydraulic-fill method, across the Beaver Brook valley to the east of the Swift River, the only break through the hills bor-

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BARRE
HARDWICK
NEW BRAINTREE
WEST BROOKFIELD
NORTH BROOKFIELD
WARE
PELHAM
NEW SALEM
COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER SUPPLY COMMISSION
SITE OF
QUABBIN RESERVOIR
JULY 1926

FIG. 1

ORANGE
ATHOL
PHILLIPSTON
WENDELL
NORTH PRESCOTT
NORTH DANA
PETERSHAM
SOUTH ATHOL
EAGLEVILLE
ATHOL
ORANGE

dering the main valley. An earth dam, similar in construction to the dike and known as Winsor Dam (named in honor of our late Chief Engineer, Frank E. Winsor), 2,640 ft long, 170 ft high and containing 4,000,000 cu yd of earth fill above the original surface, was constructed across the Swift River valley. A granite masonry spillway, 400 ft long, was constructed across a deep outlet channel, cut through solid ledge around the northeasterly end of the dam, which established the high-water mark of the reservoir at an elevation of 530 ft above mean low tide (Boston City Base).

The reservoir, which is now nearly full, floods an area of 39 sq mi of land to a depth of 150 ft at the dam and has a capacity of 415 billion gallons of water, a length of 18 miles, a shoreline perimeter of 118 miles and a total shoreline of 177 miles, including its 110 islands.

An aqueduct or tunnel, 12 ft 9 in. high by 11 ft wide, lined with concrete, was drilled underground through solid ledge from Quabbin Reservoir to Wachusett Reservoir, a distance of 24.6 miles, to connect Quabbin Reservoir to Boston's existing water-supply system. Other construction in connection with the reservoir included approximately 36 miles of new highways, a baffle dam near the aqueduct portal, two regulating dams and numerous buildings, including the Aqueduct Intake Buildings, the Winsor Dam Intake and Outlet Buildings, the Quabbin Hill Tower and Public Building, several residences and the Administration Buildings.

Of the large area acquired for the protection of the watershed of the reservoir, some 10,000 acres consisted of arable land, pasture, brush-land and gray birch sprout-land. Rather than allow this land to grow up to worthless brush and inferior species of deciduous or leaf-bearing trees, the Commission decided to organize a reforestation program, to plant these areas to coniferous or needle-bearing trees, for the purpose of better protection to the watershed, and at the same time to establish a watershed forest, which would some day produce a revenue from mature stands of timber.

The protection to the watersheds of reservoirs, afforded by reforestation with coniferous trees, is the prevention of the growth of deciduous trees, which will take place on these areas through natural reproduction, and the elimination of leaves blowing into the water,

which results in a high color and taste in the water from the decomposition of this organic material.

Coniferous forests also tend to conserve the moisture in the soil by preventing evaporation and too rapid run-off of precipitation on the watershed. During severe storms the foliage of coniferous trees catches and temporarily holds large quantities of water and also breaks up the force of heavy rain and disperses it into a fine spray which is quickly absorbed by the surface soil. Then too, in the spring, when the snow is melting rapidly in the open areas and evaporating almost entirely, while the frost in the ground prevents the soil from absorbing this moisture, it will be noted that the snow remains on the ground beneath the dense shade of the coniferous forests long after it has disappeared from the open areas and is gradually absorbed by the soil with very little loss through evaporation.

Reservoirs without the protection of coniferous forests lose a great deal of water over their spillways during periods of excessive precipitation, because of too rapid run-off, while those with coniferous forests have a more lasting supply from their watersheds as the result of the tendency of coniferous forests to retain more moisture in the soil and retard the run-off. This condition is particularly noticeable in the brooks flowing through these various types of land. During droughts, those that flow through open areas quickly dry up, those that flow through deciduous forests last a little longer but soon disappear, while those that flow through dense stands of coniferous forests continue to produce a stream of clear, cold water even after extended periods of dry weather.

General Forestry Program

A general forestry program was established in 1934, which included plans for the reforestation of all open land and areas which were growing up to brush and undesirable species of trees, on both the Swift and Ware River watersheds, the establishing of forest nurseries for growing planting stock and a general plan of forest improvement to cover the entire area acquired by the Commission for watershed protection, in connection with the Quabbin Reservoir project.

Nurseries

The forestry program was started immediately, arrangements being made to establish a forest nursery in the Quabbin Reservoir area. In order to select a suitable nursery site, an investigation was made of numerous open areas in the towns of Enfield, Greenwich, Ware and Belchertown and samples of soil from these areas were tested by physical and chemical analyses, to determine their general adaptability for nursery purposes.

Two areas were finally selected for temporary nursery sites and designated as "Twible Nursery" and "Smith Nursery," named after the former owners of the properties.

These areas were plowed and harrowed in the fall of 1934 and prepared for planting in the spring of 1935. A quantity of nursery stock, consisting of white and red pine and Norway spruce 2-year seedlings, was acquired by the Commission from the State Forest Nurseries at Clinton and Amherst and transplanted by our labor force in these two nurseries. The white pine, which had come from the Clinton Nursery, was transplanted in Twible Nursery and the red pine and Norway spruce, which had come from the Amherst Nursery, were transplanted in Smith Nursery. This stock was grown for two years in these nurseries before being used for watershed planting.

Because of the difficulty in obtaining the large quantities of trees required for our extensive reforestation program, it was decided to establish another nursery for the purpose of raising trees from seed. In the fall of 1935 a suitable area was selected on the former Thurston farm in Enfield and designated as "Thurston Nursery". This area was thoroughly cultivated that fall and, in the spring of 1936, enough tree seed was purchased to produce an estimated 3,000,000 seedlings of various species, consisting of white and red pine, white, red and Norway spruce, European larch and hemlock. This seed, with the exception of small quantities which were saved out for experimental fall planting, was planted in Thurston Nursery.

In order to have stock available for watershed planting during the 4-year period required to raise trees from seed to planting size, nursery stock was purchased, for this purpose, from various outside nurseries during this period.

In order to establish a more permanent nursery site outside of

the reservoir area, to accommodate the trees which were being produced in Thurston Nursery and to continue the production of trees from seed, another area was selected in 1936 in Belchertown near the Administration Buildings. This nursery was at first designated as "Belchertown Nursery" and later called "Quabbin Nursery."

This area included portions of several adjoining farms which had been acquired by the Commission in this vicinity. Soil tests were made over the entire area and the best fields were selected and thoroughly cultivated, fertilized and planted to cover crops of buckwheat, barley, vetch and winter rye in rotation crops during 1936 and 1937 and plowed under for the purpose of soil improvement by the addition of organic material.

In the fall of 1936 a small portion of this area was plowed and harrowed, seed beds were prepared and the seed, which had been saved out of that purchased in the spring of 1936 for the purpose of experimental fall planting, was planted in these beds.

In the spring of 1937 the entire stock was removed from the Twible and Smith Nurseries and used for watershed planting and these nurseries were discontinued.

Tree seed was again purchased in the spring of 1937, consisting of white and red pine, white, red and Norway spruce, European larch and hemlock, and this seed was planted in Quabbin Nursery. A portion of it was planted in the spring of 1937 and the remainder was planted in the fall of that year.

In the spring of 1938 the entire stock was removed from Thurston Nursery and this nursery was discontinued. . The 4-year transplants were sent out for watershed planting and the 2-year seedlings, which had been raised from seed, were transplanted in Quabbin Nursery in Belchertown. When the total number of seedlings had been counted, it was found that they had exceeded our originally planned production of 3,000,000 seedlings by 4.5%.

From 1938 to 1941 tree seed was purchased each spring and new seed beds were planted in Quabbin Nursery, to keep a continuous supply of two to three million trees coming along each year for watershed planting.

After 1941 it was necessary to suspend this work because of the war emergency and the resulting shortage of labor and materials.

Treatment of the Seed Previous to Planting

Because of the peculiar characteristic of some species of trees, including the white pine, white spruce and hemlock, whose seeds are not fully developed when they fall from the trees but complete the process on the ground during the winter, a special treatment was applied to the seed of these species which is called "after-ripening".

This treatment was started about the middle of March. The seed was placed in cloth bags and soaked in water overnight to soften the seed coats. The bags were then hung up and allowed to drain. After draining thoroughly, the seed was soaked in a "normal Semesan solution", consisting of one level tablespoonful of Semesan powder (hydroxymercurichlorophenol 30% and inert ingredients 70%) to one gallon of water. The pine seed was soaked for 90 min and the spruce and hemlock seed for 30 min, after which the seed was again allowed to drain. The latter were soaked for a shorter period because of thinner seed coats. The purpose of soaking the seed in the Semesan solution was to destroy the spores of the fungi which cause a serious wilting disease among the seedlings, known as "damping off." These spores are often present in the seed coats. The seed was then spread out on a canvas and stirred around until it was just dry enough to prevent it from sticking together.

While the seed was being prepared in the above manner, a quantity of clean dry sand, free from loam, was sifted through a fine screen and sterilized with a solution of one pint of acetic acid in 20 gal of water, this solution being well mixed with the sand in a mortar box and allowed to drain thoroughly. The seed was then stratified in the sand by placing alternate layers of about one-quarter inch of sand and thin layers of seed in shallow boxes, with sand on the bottom and top. The seed and sand in each box had been previously weighed separately, to facilitate later planting with the proper density of trees in the seed beds. The boxes were then covered with a screen to prevent destruction by mice, placed in a cold cellar which maintained a fairly constant temperature of around 40 to 45°F., kept slightly moist and turned over occasionally to aerate the seed. It was allowed to remain in this condition for a period of five to six weeks before planting in the seed beds, depending on the general appearance of the

seed—that is, if it started to show signs of germinating in the boxes before the end of the six-week period, it was planted immediately.

Germination tests were made on both the stratified and unstratified seed of the white pine, white spruce and hemlock, to determine the effect of the after-ripening process on the seed.

The results of one of these tests are as follows:

Species	Stratified	No. of days	Germination (%)
White pine	No	20	46
	Yes	20	79
	No	58	79
	Yes	58	85
White spruce	No	10	5
	Yes	10	53
	No	58	87
	Yes	58	77
Hemlock	No	25	4
	Yes	25	22
	No	58	24
	Yes	58	46

These tests and other experiments in fall planting of these species indicated that after-ripening was quite essential in the case of the hemlock seed, if it were to be planted in the spring. In the case of the white pine and white spruce seed, however, although it speeded up the germination considerably and got the seedlings off to a much earlier start in the spring, which for that purpose alone might make the extra work worth while, the stratified white pine seed showed only 6% more germination than the unstratified in the final outcome and the white spruce seed showed 10% less germination at the completion of the test.

It was found that just about as good results could be obtained by planting the seed of these species in the fall, around the first of October, and allowing the after-ripening process to take place as nature intended it to—by having the seed remain in the frozen ground under the snow all winter. A big advantage in the fall planting also was that this work could be done after the other nursery work was about completed and it eliminated the work of treating the seed, constructing extra seed beds and planting the seed of these species

in the spring, when the rush of the other nursery work was on. The only point against fall planting is the risk of getting a stretch of unseasonably warm weather for two or three weeks after the seed has been planted, which might result in the germination of some of it and the consequent loss of the seed. This condition, however, is a rare occurrence where the seed is planted so late.

Preparing the Seed Beds and Planting the Seed

The seed beds were prepared in an area which had been previously plowed, harrowed and fertilized. Parallel beds were laid out, with stakes and string, 4 ft wide and 100 or 150 ft long, the length depending on the space available, with 2-foot paths between beds. The beds were laid out in multiples of 50 ft in length, because the rolls of snow fence used for covers were 50 ft long. These strips were thoroughly raked over and all stones and pieces of sod removed. The beds were raised about 2 in. above the level of the paths and rounded up so that the centers were slightly higher than the sides, to facilitate good drainage. Eight-inch boards, 12 ft long, were then laid edgewise along the sides of the beds and held in place by 2″ x 2″ stakes, driven into the ground at the ends and in the middle of each board on the outside, and by 1″ x 4″ stakes, driven into the ground opposite these on the inside. These side boards were placed 45 in. apart in order to support the 48-inch snow fence, which was used for shade covers for the seedlings.

After the seed beds had been carefully shaped up and smoothed over, they were tamped to break up the lumps in the surface soil and were then scratched over lightly with a rake. The white pine, white spruce and hemlock seed, which had been stratified, was measured out into the desired quantities, without separating it from the sand, and broadcast by hand over the beds as evenly as possible. The other tree seed, which had not been stratified, was soaked in a normal Semesan solution, the red pine and Norway spruce seed being soaked for 60 min and the European larch seed for 30 min. The seed was then drained, partially dried and broadcast in the beds in the proper quantities to produce the desired density of seedlings per square foot.

The following formula was used to determine the amount of seed

required to produce the desired density of seedlings per square foot in the beds:

$$\frac{A \times N}{S \times P} = Q$$

Where A = the area of the bed in square feet;
N = the number of seedlings per square foot;
S = the number of seeds per pound (as determined by sample counts);
P = the percentage of germination of the seed (as determined by previous tests);
Q = the quantity of seed in pounds.

A small amount of seed was added to take care of some expected loss after planting.

A thin layer of fine, sandy loam subsoil, just enough to cover the seed, was then sifted on the beds and rolled with a medium-weight roller, to press the seed into firm contact with the soil. The subsoil was used in order to eliminate as much of the "damping-off" fungus as possible, which is generally more prevalent in the topsoil. A layer of good clean sand, free from stones, was then spread over the beds about ¼ in. deep and the beds were rolled again. They were then thoroughly sprinkled and covered with snow fence. Strips of burlap were placed over the snow fence and the beds were kept covered during the germination period. They were carefully inspected every two or three days to see that proper moisture was maintained.

As soon as the seedlings were observed breaking through the ground quite generally throughout the beds, the burlap was removed and the snow fence left in place. Care was taken not to uncover the beds on a bright sunny day. As soon as the covers were removed, the beds were sprayed with normal Semesan solution (1 lb of Semesan to 48 gal of water) at the rate of 5 gal per 35 linear feet of seed bed, to destroy any "damping-off" fungi which might be present in the surface soil. The beds were then watched closely and, if "damping-off" began to appear among the seedlings after the initial spraying, one or two later sprayings were applied at intervals of several days.

Care of the Seedlings

All of the seedlings, including the hemlock, were at first grown for two years in the seed beds before transplanting but it was found that better results were obtained with the hemlock by growing these seedlings for three years in the seed beds, because it was necessary to keep them covered with the snow fence throughout the first two seasons and gradually to expose them to full light during the third season. The other seedlings were gradually exposed to full light during the first season by starting the first of August to roll back the snow-fence covers for short periods on sunny days and by leaving them off entirely on cloudy days, the length of exposure being gradually increased until by the middle of September the covers were left off entirely, in order to harden up the seedlings for the winter. Throughout the summer months the seedling beds were kept well weeded and were sprinkled whenever necessary during dry weather. In the late fall of the first season, after the ground had frozen, the seedlings were covered with a light layer of straw and the beds were covered with snow fence and burlap for the winter. The covers and straw were removed as soon as the beds thawed out in the spring. During the second winter the pine, spruce and larch seedlings remained uncovered and the hemlock seedlings were covered only with the snow fence.

Control of Diseases and Insect Pests in the Seedling Beds

No serious trouble was experienced in the seedling beds with either diseases or insect pests. However, as a safeguard against the most destructive disease to which the red pine is susceptible, known as "Lophodermium Pinastri" or "Leaf Cast" disease, these seedlings were sprayed with a lime-sulphur solution (Bordeaux mixture) several times during the growing season of each year.

The mixture used is as follows:

4 lb of copper sulphate (powdered form)
5 lb of hydrated lime
25 gal of water
1 lb of powdered casein soap spreader

Occasionally the larch seedlings were attacked by the larva of

the larch sawfly and, when these were discovered, the larch seedlings were sprayed with a solution of arsenate of lead, mixed as follows:

½ lb of arsenate of lead
25 gal of water
1 lb of casein soap spreader

Transplanting the Seedlings

After the seedlings had been allowed to grow in the seed beds for two or three years, depending on the species, they were removed in April and May of the following year and transplanted into new beds in the nursery.

An area was well prepared by plowing and harrowing, removing the stones and carefully leveling and smoothing over the surface with rakes. The beds were then laid out, 4 ft wide in parallel strips, with two-foot paths between the beds. A string was stretched along the right-hand edge of each bed and tied to stakes at either end, to assist the planter in keeping his rows straight.

The transplant board used was one developed at the State Nursery at Massachusetts State College in Amherst. This board is 48 in. long, 6 in. wide and ⅝ in. thick. Wire loops are tacked along the front edge of the board, with ½-inch spaces between these loops to hold the seedlings in place, at the proper spacing to allow for 30 trees per row. An iron rod is attached on hinges to the top of the board at the back edge and this rod drops down over the trees and against the front edge of the board, to hold the seedlings solidly in place during the process of transplanting.

The method of transplanting the trees is as follows:

The planter gets down on his knees in the center of the bed and places the board at right angles to the string along the side of the bed, with the wire loops on the board facing him and the iron rod tipped up. He digs a trench with a trowel about 6 in. deep along the edge of the board, takes a handful of seedlings from a pail by his side and places a seedling in each slot between the wire loops, with the roots hanging down into the trench. He then tips the iron rod forward and down into place against the trees along the front edge of the board, where they are held in place while he pushes the dirt back into the trench with his hands and packs it down firmly. He then lifts the rod and tips it back, lifts the back of the board up and away from him, slipping the wire loops out from under the tops of the trees. He then brings the board forward and places it with the back edge along the row of seedlings he has just planted and is then ready to start another row in the same manner.

Care of the Transplants

The transplant beds were kept free from weeds and well cultivated and, during the early part of the second season, a light application of 5-8-7 fertilizer was sprinkled between the rows of trees and worked into the soil.

The red pine transplants were sprayed with Bordeaux mixture several times during each growing season, to prevent "leaf cast" disease, and both the red pine and European larch were sprayed occasionally with arsenate of lead solution for insect control.

In the early spring of the fifth year, as soon as the frost was out of the ground, the transplants, which were ready for watershed planting, were lifted, tied in bundles of 25 each and heeled-in in trenches in the nursery, ready to be sent out in the field to the planting areas.

Watershed Planting

Watershed planting was started as early as possible in the spring and continued until about the first of June, when the new growth on the trees was too far advanced to allow further handling. The trees were loaded on trucks at the nursery and taken to some point as near as possible to the planting areas, where they were either heeled-in in trenches or placed in nearby brooks or water holes.

When the men were available, the planting crews were divided into 22 men each, with a foreman for each crew. These crews were divided into 10 two-man teams, with one man digging the holes and the other following along behind, planting the trees. The remaining two men kept the planters supplied with trees and the foreman followed along behind the planters, to check the planting and see that the trees were set solidly in the ground and planted at the proper depth and spacing.

The planting teams were lined up at the edge of a field and were started off with a lead man, at the left end of the row, who was experienced in keeping the line straight and the trees at the proper spacing of 5 ft apart on centers. The rest of the planting teams followed along in echelon formation, so that each digger could gage his row by the one on his left.

The trees were carried in 10-quart pails, which held two bundles, or 50 trees each.

The planting tool used is known as the "Harvard planter", developed by the Harvard Forestry School. It has a chisel-shaped blade, 6 in. wide and 8 in. deep, attached to a straight, cant dog-type handle, 4½ ft long.

The digger holds this tool in front of him with the blade parallel to the row and, with a plunging stroke, drives it into the ground the full depth of the blade and then pushes the handle to the right and left, making a hole in the ground in the shape of an inverted "V" with a narrow opening at the surface. The planter inserts the roots of the tree into this opening, pushes it down to force all of the roots to the bottom of the hole, then lifts the tree up to the proper planting depth and, while holding the top upright, he stamps on either side of the tree with his heel, to close the hole and pack the soil tightly around the roots.

The planting crews have averaged between 900 and 1,000 trees per day per man, using this method of planting, and the survival of trees in the plantations has averaged around 90 to 95%.

Some of the things we have learned from studies of the trees in our plantations are as follows:

1. The spruce and European larch are susceptible to damage from deer, if the latter are numerous in the area, as they eat the tops off these trees when the new growth is soft in the early summer.

2. The European larch is also susceptible to frost damage and low frost pockets must be avoided in planting this species. It is also susceptible to severe damage where porcupines are numerous, as they eat the bark of this species ravenously and strip many trees clean the entire length of the trunk, killing them immediately.

3. Considerable damage is done to white pine, red pine and hemlock by the caterpillar of the gypsy moth, during seasons when infestations of this pest are unusually heavy. Some control has been attempted by roadside spraying with arsenate of lead solution but this had little effect, because many of the worst areas could not be reached. We await the coming of airplane spraying with DDT to eliminate this pest.

4. The white pine is very susceptible to the white-pine blister

rust, which is controlled by the systematic eradication of the host plants of this disease—the gooseberry and currants which are known as *Ribes*—for a safe distance around the pine plantations and natural white-pine stands on the watershed. The white pine is also badly damaged by the white-pine weevil, which destroys the leader or tip of the tree when it is small and ruins the tree from the standpoint of producing timber of good quality. This pest is controlled to some extent by cutting and burning the infested tips while the larvae of the weevil are still active during the early summer.

5. Hemlock and red spruce do best when planted under partial shade and are well suited for planting under existing stands of gray birch.

To date, approximately 10,000,000 trees have been produced in our nurseries and planted on the Quabbin Reservoir and Ware River watersheds and, as the result of this program, approximately 9,000 acres of land have been transformed, by reforestation, from unproductive waste-land to dense coniferous forests, ideal for watershed protection as well as potential timber-producing areas of great future value.

Discussion*

Wendell R. LaDue‡ (Akron, O.). Russell Snow's paper, "Reforestation on the Quabbin Reservoir Project", is another valuable contribution to the literature and knowledge on the subject of watershed and reservoir use. Such discussions are valuable to all waterworks men who have land areas under their supervision, regardless of whether such areas may be 5 acres or 50,000 acres in extent.

Forty years ago President Theodore Roosevelt warned this country of its depletion of forest areas. Thirty years ago the same warning was sounded by Gifford Pinchot, then Governor of Pennsylvania. The American Forestry Association has, for many years, warned the public of the depletion of forest cover throughout the United States. Until recently, very little had been done on this national problem. A few courageous water-works men have been pioneers in reforesting their own watersheds but, over the past 25 years,

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this work almost invariably has been done in the face of disapproval. The city of Akron's practice is outlined in the publication "Water Works and Sewerage" for June and July, 1945. Further discussion on this subject appeared in "Water Works Engineering" for May 2, 1945.

Of the water-works manager who has available to him lands for reforestation, there are several pertinent questions to be asked:

1. Is the development for economic profit?
2. Is reforestation to be used for watershed control?
3. Is reforestation to result in reservoir protection and water improvement?

Each question should be asked and answered carefully and the answers will dictate in great measure the type of project.

Let us now consider a few pertinent admonitions.

I—*Know Your Watershed.* Catalog it carefully as to existing forests and present cover. Existing species are the end-result of Nature's selection and, therefore, the replanting of such species may be expected to survive. In other words, existing cover is Nature's summation of her past experiments. Introduction of *new* species under such circumstances may be experimental only.

II—*Study the geology of the watershed or reservoir areas.* Many species naturally select certain geologic strata for most favorable growth. Topography and drainage enter into the natural selection of the locale by such trees as tulip, poplar, tamarack, larch, pine, chestnut, maple, elm and oak.

III—*Consider erosion and run-off control.* Ground cover is essential to erosion control. However, transpiration through many species can actually reduce total run-off. On the other hand, certain covers may reduce quick run-off and prevent erosion but they also produce delayed run-off and the retention of ground water for later hot-weather flow. In this way, direct beneficial results are effected.

IV—*Do not underestimate the value of shrubs and grasses.* Many shrubs and grasses provide excellent cover for erosion control and the retention of water, though it is a well-known fact that many grasses produce high transpiration losses. On many watersheds, it is the desire of the manager to encourage wild life by providing suitable

cover and natural food. This is often-times best accomplished through the planting of berry- and nut-bearing shrubs and grasses.

V—*Call upon state and national forestry and agricultural agencies for assistance.* Many state and national bureaus are in position to furnish valuable information resulting from long-time experiments and study. In a paper delivered recently at the Southeastern Section meeting of the American Water Works Association at Savannah, Ga., Charles R. Hirsh of the United States Department of Agriculture at Asheville, N. C., explained the valuable experiments now underway, dealing with the important topic of forest control on watersheds.

VI—*Do not forget that timber is a valuable crop.* Timber grows and finally reaches maturity, then recedes in value. It is, therefore, very important that the crop be harvested at its prime and that reforestation of the cropped area be accomplished at once, for in this way a continuous crop of great value is assured. Let us not allow slow growth to discourage us. We should not try to measure the life-span of a tree by man's short existence.

These items and others of like nature should be pursued further.

Again allow me to congratulate Mr. Snow upon his paper and to repeat that managers, who have areas of land under their control, should study their watersheds and reservoirs, to determine the possibilities for constructive and long-term reforestation developments. The results are gratifying and ofttimes astounding.

OKINAWA WATER TREATMENT PLANTS

BY E. W. CAMPBELL*

[*Read September 19, 1946.*]

WHEN planning the Okinawa campaign, one of the principal problems was to develop plans for the protection of safe and adequate water supplies, which would not transmit disease to our troops and thus impair their military efficiency. Information furnished by travelers and others indicated that we could anticipate extremely polluted water supplies and that all available methods of purification would probably have to be utilized, in order to produce an acceptable and safe water for domestic purposes. It was known that the universal Oriental habit of night-soil use was prevalent in this area and it was further known that the incidence of various sewage-borne diseases was very high. Exact knowledge of the composition of the water to be treated was practically nil, although some conclusions could be drawn from existing information concerning the geographical structure of the island and the conditions which were likely to prevail as a result thereof. It was known that the island was apparently caused by a fold of the earth's crust, rather than by volcanic action, and that there were numerous limestone escarpments and areas of limestone, presumably of coral origin, which had risen out of the ocean bed. Whether or not the water was acid or alkaline was not known, nor whether or not it would be necessary to contend with high concentrations of vegetable colors. Sufficient amounts of alum, soda ash, activated carbon and calcium hypochlorite were requisitioned to treat all water which we anticipated using and a large number of stills, designed to produce water from sea water or brackish shore water, were also provided. It was anticipated that for the first few days water would be provided from the fleet and the assault troops would carry ashore with them in cans a few days' supply.

The first water plant that was set up consisted of a number of 3,000-gal-per-day stills, set up at the confluence of a river, where two

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small branches came together at the head of tide, which we called the Bisha Gawa. Just as rapidly as possible after organization equipment was taken ashore, water-source sites were located and field filtration plants set up. The first units consisted of a combination pump, hypochlorinator and chemical-feed unit, to feed chemicals while pumping the water from the source to sedimentation-coagulation tanks—which were 3,000-gal canvas tanks—one or more pressure-type sand filters of normal 15-gpm capacity, and one or more 3,000-gal canvas tanks for clear-water storage. In normal operation, after settling for not less than an hour in the sedimentation-coagulation tanks, water was pumped through the pressure sand filters to the storage tanks, from which the water was pumped or, if the topography permitted, drawn by gravity to trucks for distribution.

It was found at once that the water was very hard, containing large amounts of calcium bicarbonate, and that in most instances alum alone was sufficient for coagulation, varying in amounts from 2 to 8 grains per gallon. This method required a number of canvas tanks, to provide for detention and settling, in accordance with the number of filters available. Very quickly we found we were faced with a shortage of such tanks. Some were lost through enemy action, some simply never did arrive for unexplained reasons, and there was always the extremely short life of such tanks in a hot, humid climate, where canvas deteriorates very rapidly. In fact, if any tank lasted over a month we considered it doing well, although, with repeated applications of waterproofing, some tanks would actually function for as much as six months. Whenever sufficient amounts of crating or other dunnage could be secured, tanks were elevated off the ground and their life was proportionately increased.

Part of this shortage was anticipated and, while making preparations in Hawaii for this campaign, experimental work was done in an effort to provide a continuous-flow method, utilizing the ordinary 3,000-gal canvas tanks which were available. This method was published in a bulletin, which was distributed to all of our subordinate commands, and we immediately started to put it in practice. Instead of pumping the tanks full very rapidly and then leaving them to coagulate and settle for an hour, which was the normal method, water was pumped into these tanks at a constant rate, based on the capacity

of the filters available, but not less than 10 gpm nor more than 30 gpm for each coagulation tank. Water was pumped through an ordinary hose, connected to the drain at the bottom of the tank, which had attached to it on the inside of the tank an elbow, connected to a short length of hose, which was laid on the floor of the tank around its outer circumference. The water issuing from the hose imparted a circulatory motion to the water in the tank and caused it to flow spirally upward. Water was withdrawn through a bucket, suspended in the exact center of the tank from a piece of joist or other timber laid across the top of the tank, the bucket being submerged about six inches to a foot below the level of the liquid, its rim, however, being just above the surface of the water. The suction hose of the filter pump was likewise suspended from the joist, with the end inside the bucket, and by withdrawing water in this manner assisted in creating and maintaining the circulatory motion of the water in the tank. With this system, a constant flow of 30 gpm from each sedimentation-coagulation tank could be secured.

The usual type of portable filter, with a normal capacity of 15 gpm, was operated at 10 gpm, so that one unit with the system described consisted of one chemical-feed pump, one 3,000-gal tank and three pressure filters. If possible, an additional 3,000-gal tank was provided, for storage of the filtered water, but if they were not available water was pumped directly to trucks.

It was found very quickly that the hose, lying on the floor of the tank, created too much agitation and prevented adequate settling of the coagulated water, even though the rate of flow through the tanks was slow enough so that coagulation and sedimentation could have taken place without any difficulty. To overcome this, the drain in the base of the tank was recapped and the hose lying on the floor of the tank was removed. In place of that arrangement there was constructed a wooden box, built from ordinary box boards—which was all that was available—approximately a foot square and as long as the tank was high. The bottom of this box was nailed tight and, starting 3 in. above the base of the box, a series of about four rows of holes was bored on one side of the box. These holes were necessarily of the size for which we had bits available and generally we used ½- or ¾-inch augers, spacing the holes about 3 in. apart. As

a result, the water then left the box through an area approximately one foot square. The box was placed at the outer edge of the tank, with the top attached to the timber previously described, which was laid across the tank and so arranged that the side of the box containing the holes was directed towards the periphery of the tank. The water issuing through these holes created a circulatory motion to all the water in the tank, eventually being removed through the bucket described above. Due to the lack of flanges, couplings, plugs, etc., it was necessary to lead the water into the box by simply dropping the hose from the chemical-feed pump down through the top of the box to a position somewhere near the bottom. This also provided for excellent mixing of the chemicals and it was found that, in rates of flow between 10 and 30 gpm, we still maintained a spiral movement of the water through the tank, with practically no cross-circuiting. It was also found by test that the detention period was over an hour when the tank was operated at the rate of 30 gpm. Of course, lower rates of operation gave longer periods of detention, which was to our advantage but was seldom utilized, because we had to operate all equipment at maximum capacity to produce even a minimum supply of potable water.

This scheme was highly satisfactory and was rapidly adopted by most of the water plants. A few truck-mounted filters of larger capacity began to arrive after a few months and then two, or even three, sedimentation-coagulation tanks were equipped and put in use in exactly the same manner as previously described, the flow being divided by means of wyes. These worked equally well for filters operated up to 60 gpm.

For a number of months all the water furnished to our troops was provided in this manner. In the meantime, plans were being laid for developing permanent filter plants and for repairing such municipal installations as were formerly in use by native cities. One slow sand filter plant formerly used by an alcohol mill, which produced alcohol from sweet potatoes, was rehabilitated and functioned fairly satisfactorily. This plant consisted of a sedimentation chamber, which was well baffled and permitted a detention period of not less than 6 hours when operated at full capacity, and two filters which had an estimated total capacity of about 300,000 gal per day. The first unit was found

to be relatively undamaged and, after it was operated for a couple of weeks to waste, a good "schmutzdecke" was developed in the filter. Filtered water was then offered for distribution.

As in the case of every filter plant, a high-residual chlorine dosage was maintained. I have not previously mentioned the chlorine dosage but perhaps this is as good a place as any to discuss it. It was found that the natives had a rather high incidence of amoebic dysentery and approximately 13% were carriers. With the highly polluted condition of every type of water supply we knew we could anticipate outbreaks, unless extreme precautions were taken. For this reason we decided, if possible, to work on a basis of break-point chlorination and we found that this could be accomplished with most sources by using 3 to 5 ppm of chlorine with 1 to 2 hours' detention. That being the case, a sufficient amount of chlorine was added, at the same time the alum was added, to produce a chlorine residual of not less than 2 ppm after filtration and to maintain not less than 1 ppm in the water leaving our clear-water storage tanks. This may seem extraordinarily high to those of you who are accustomed to adding 0.1 to 0.5 ppm of chlorine and maintaining a residual so low as to be at the lower limits of measurability. We believed, however, that if we did not maintain a sufficient amount of chlorine to provide for some sterilizing effect in the water after it left our water treatment plants, we could anticipate re-contamination of the water by cans, tank trucks and dispensing faucets, followed by outbreaks of sickness which would defeat the purpose of purification accomplished by the filter plants.

Surprisingly enough, the chlorinous tastes were not very objectionable, causing annoyance only in the kitchens when water used for making tea or coffee was not boiled for a few minutes to dissipate excess chlorine. Many times people complaining of these tastes were informed that they could eliminate them by taking such action but still we received plenty of "gripes" concerning this feature, not because the water tasted badly but because the tea and coffee did. Everybody appreciated the necessity of the treatment but naturally did not like some of the inconveniences. Many times we had minor outbreaks of amoebic dysentery and other intestinal water-borne diseases, which were invariably traced to small groups of individuals who had taken water from sources that were not adequately treated.

Many prefabricated water plants had been ordered but for various reasons did not arrive on the target until well along in the summer. A typical plant of this type consisted of a gravity sand filter of 50-gpm capacity in a circular wood-stave tank, approximately 8 ft tall by 5 ft in diameter, and two wood-stave storage tanks, one for coagulation and the other for clear water, generally utilized as a storage tank for back-wash water. Each of these units was provided with two wood-stave chemical-mixing tanks of about 20-gal capacity with four chemical feeders, which could be used for feeding hypochlorite, alum, soda ash or any combination of these. All pumps were provided in duplicate, to guard against breakdown and to insure continuous operation while making repairs. As soon as they were available, additional storage tanks were set up at each plant, generally wood-stave tanks of capacities from five to 20,000 gallons, and gradually a few distribution systems were developed. For the greater part of the operation, however, the water was drawn from dispensing hoses directly to water-cans, tank-trucks or similar vehicles and transported to the various units for consumption. These plants functioned very satisfactorily and could be depended upon to produce a constant supply at their rated capacity of 50 gpm. In a considerable number of instances two, and even three, such units were set up at one site, so as to get greater capacities.

Another type of plant which was utilized to some degree was the diatomite filters. These consisted of a pressure-type filter, containing a closely spaced wire septum or porous porcelain, instead of the graded sand in the ordinary type of pressure filter. To operate the plants it was necessary to provide a slurry of diatomaceous earth, which was pumped through the filter until a coating was built up on the filter plates sufficient to act as a filtering medium. Then, during the entire run of the filter, it was necessary to add continuously a small amount of this slurry in the same manner that we might add lime for correcting the pH in an ordinary water system. The filters were rated at capacities of 25 or 50 gpm and, for the first two or three minutes after being placed in operation, would produce the rated capacity but they very rapidly slowed down, due to the accumulated coating of diatomaceous earth, so that in a few minutes the capacity would decrease to a point where they were no longer efficient. This

time varied from 20 minutes to ¾ of an hour. When the flow got as low as 2 or 3 gpm, it was necessary then to wash the filters and start over again to build up a new coating, in the same manner as at the initial start of the filter. Theoretically, and according to information furnished to us, these filters eliminate cysts of amoeba as well as producing a water of extremely low turbidity. Owing to the extreme prevalence of amoebic dysentery as well as the bacillary types of infections, none of us wished to take any chances or do experimental work in the field where the consequences might be disastrous, so that with all these filters we required initial treatment with alum and hypochlorite, with detention in a settling tank for at least an hour before filtering, even with the diatomite filters. Such procedure further reduced the capacity of these filters by reason of small amounts of alum floc carrying over onto the filters. This really was not a material factor, as we found out by operating some of the filters to waste for a while, to see how much reduction in flow there was, due to the alum floc.

Much information was furnished as to the desirability of these systems over the sand-type filters but, at least from the experience which we had, it appeared that the ordinary sand-type filters were far more practicable in forward areas. Under other circumstances, with an assurance of an ample supply of thoroughly trained personnel, it may be possible to secure a non-turbid, bacteria-free water by use of diatomite filters, in reasonable amounts, according to the capacities of the equipment provided. However, in areas where trained personnel cannot be assured, such as in combat or in areas where there is a rapid change of personnel, this becomes impracticable and the quantity of water produced by these systems was far less than their estimated capacity. In our area the pressure-type sand filter or gravity-type sand filter was able to produce a safe water with very low turbidities and continuously produced the rated volume, even under adverse conditions with relatively few trained personnel.

Considerable ingenuity and initiative were shown by many water-plant operators in developing plants from scarce materials. One plant operator salvaged a steel tank, 4 ft in diameter and 5 ft high, and out of this constructed a filter by installing a crowfoot underdrain and distributing pipe. This was made out of the ordinary two-inch steel

pipe and all connections, joints and openings were made by means of an acetylene welding torch. Beach sand was used as a filtering medium, which worked fairly satisfactorily, although it was highly calcareous and somewhat inclined to be flaky. This plant operated very satisfactorily at a rate of 35 gpm and somewhat less so at 50 gpm. The balance of the plant was constructed entirely from salvaged electric motors, retrieved from a burned and demolished Japanese sugar mill, power being supplied by a Diesel generating unit. This was the only all-electric water system developed in that area.

Another water plant of interest, developed by a Naval construction unit, was designed to supply island headquarters and adjacent areas. An 11,000-gal wood-stave tank was converted into a gravity-type rapid sand filter, beach sand being used as a filter medium. Underdrains and water-distribution pipes were fabricated by welding eight-inch steel pipe. Another 11,000-gal wood-stave tank was used as a coagulation-sedimentation tank. A similar tank was set up on a hillside with sufficient elevation to give a pressure for back-wash water. It was anticipated that this filter could be operated at a rate of 350 gpm, even with the poor grade of sand available. In practice, the peculiar location of this plant in a deep ravine was limited by the capacity of the high-pressure pumps.

The source of water was a small brook. The larger part of the distribution system was about 400 ft above the filter plant and the storage reservoir, which floated on the line, was about 450 ft above the filter. With this high head our delivery capacity was approximately 250 gpm and consequently the filters were operated at that rate. A very satisfactory quality of water was produced from this plant under those circumstances.

The largest plant developed on the island was that established to supply the east side of the island and was designed locally, but all materials were requisitioned from the United States. This was a regular 6-mgd filter plant with circular steel tanks both for sedimentation-coagulation tanks and for filters. It was designed to be set up by Naval construction units under the direction of the island engineer. I do not have the details of this construction, although there appeared to be no particularly unusual features of the plant, other than diffi-

culties of construction and of securing materials at a distance of 6,000 miles from the nearest source of supply.

In presenting this information concerning the water plants on Okinawa, I realize that I have very briefly described the types of plants which were installed and, for lack of detailed information, have not been able to give you an engineering report on the details of construction of the various units. However, if this paper has given you a glimpse of the problems involved and the difficulties encountered in supplying water in an adverse environment and, in spite of all these difficulties, producing a water supply which at least was safe and non-infectious, I have accomplished my purpose.

PROBLEMS AND PROGRESS IN HANDLING STREAM-POLLUTION ABATEMENT IN CONNECTICUT

BY WARREN J. SCOTT*

[*Read September 19, 1946.*]

State Agencies

IN CONNECTICUT, there are two agencies concerned with pollution abatement. One of these is the State Department of Health, which is concerned with the health aspects of water pollution, particularly adverse effects on sources of potable water supply, bathing waters and shellfish-growing waters. Certain nuisance aspects of water pollution also come under the purview of local and state health agencies. The State Water Commission is concerned with broad phases of water pollution as affecting water use and conservation, such as effect on fish life, use of water for industry, objectionable conditions resulting in damage to property, or interference with navigation or boating.

Close coöperation has existed between the two state agencies to avoid overlapping of activities. The State Department of Health exercises supervision of operation of public sewage-treatment plants, as to absence of nuisance and of objectionable conditions from plant operation. Serious operating deficiencies are reviewed by both state agencies. Industrial-waste disposal problems are handled almost exclusively by the State Water Commission, except in so far as the health department is also concerned with possible adverse effects on public sewage-treatment plant operation from industrial-waste discharge into public sewers or unusual conditions which might directly affect the public health. Both agencies must approve plans for new public sewage-treatment plants or plant alterations and the two agencies work closely together on review of plans.

State Laws

For many years there have been laws on the statute books giving the State Department of Health broad powers: to act in case of pollu-

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tion adversely affecting the public health, to compel the proper operation of public sewage-treatment plants, to require alteration, extension and replacement of plants when necessary for the protection of the public health, and to pass on plans for new public sewerage systems. Also, the law provides that the qualifications of operators of sewage treatment plants are subject to the approval of the State Department of Health. Certain minimum qualifications have been established by the department. Supplementing the duties of the State Department of Health, local health officers are empowered to abate nuisances and to take emergency measures when necessary for the protection of public health. [See Sections 2546, 2547 (amended by Section 998c), 2548, 2549, 2550 and 2551 of the General Statutes for laws relating to the State Department of Health.]

The State Water Commission, consisting of three members appointed by the governor with the approval of the Senate, is empowered to make orders after hearing, directing any person, firm or corporation to use or to operate some practicable and reasonably available system or means which will reduce, control, or eliminate pollution, having regards for the rights and interests of all persons concerned, provided the cost of installation, maintenance and operation shall not be unreasonable or inequitable. The law further provides that orders issued by the commission shall specify the particular system or means to be operated, provided if there shall be more than one practicable and reasonably available system or means, the orders shall give to the person, firm or corporation the right of choice. The commission is empowered to require any town, city, borough or sewer district to cause a preliminary engineering survey to be made for determining the cost of correcting pollution prior to the issuance of an order by the commission, the results of the survey to be submitted to the commission. At the time the commission was established, a law was enacted prohibiting any new sources of pollution (since 1925) without approval of the commission. A law also prohibits dumping of refuse within 50 feet of streams without approval of the commission. [See Sections 2547 (amended by Section 998c), 2553, 2554, 2555 (amended by Section 932e), 2556, 2557 (amended by Section 999c), 2558, 2559 and 2560 of the General Statutes, for laws relating to the State Water Commission.]

Interstate Sanitation Commission

Connecticut, New Jersey and New York are joint members of the Interstate Sanitation Commission. The anti-pollution compact subscribed to by the three states is set forth in Sections 372f, 373f and 374f of the General Statutes of Connecticut. Other state laws, Sections 375f to 383f, inclusive, provide for the appointment of the Connecticut membership of the commission and specify their duties. One member of the commission is the state commissioner of health,* another member is the director of the State Water Commission,* a third member is the attorney general and the other two members are appointed by the governor. No detailed description of the compact is possible within the brief space of this discussion. However, it is of interest that no order issued by the commission is effective until the majority of the commissioners from each state approves the order. Also, the Connecticut law provides that before the commission may issue an order, they must first give notice in writing of the discharge of sewage or polluting matter, to the State Water Commission and to the State Department of Health, for such action as may be proper under the laws of the state of Connecticut. If, after the expiration of six months after the mailing of such notice, conditions are still objectionable, the commission may issue orders. The formation of the commission and its activities have undoubtedly added to the effectiveness of action taken by the various states in the Interstate Sanitation area. In Connecticut this area extends from the New York state line to and including New Haven Harbor. Close coöperation has existed between the commission and the state agencies.

Progress in Municipal Sewage Treatment

Most of the larger communities and many of our smaller communities already have sewage treatment, although some plants need alteration and enlargement. In recent months the state has approved plans for new sewage-treatment plants in nine communities. In addition, plans and specifications for sewers and sewage treatment are in the process of preparation in fifteen communities. The remaining communities discharging untreated sewage or needing plant enlarge-

*The state commissioner of health is Stanley H. Osborn, M.D., and the director of the State Water Commission is Richard Martin.

ments have under active consideration the preparation of plans and specifications for needed work. Conferences between the state agencies and municipal officials are constantly being held to promote this. Also, plans for new sewers in unsewered areas are in preparation in some areas.

Progress and Problems in Industrial-Waste Treatment

The discharge of industrial wastes into municipal sewers has in some instances created operating problems at municipal sewage-treatment plants. Particular difficulties incurred have been due to the presence of materials tending to inhibit sludge digestion, materials that create an abnormally high chlorine demand, and materials of a fibrous nature that do not lend themselves to digestion processes. The treatment of many industrial wastes continues to be a serious problem, both from the standpoint of lack of technical progress and from the standpoint of economics. While in certain industries, such as the paper industry, there has been considerable accomplishment and salvage of materials has been possible which has resulted in a reduction of treatment costs and sometimes in savings, in other industries effective treatment methods are not known, certainly within any range of reasonable cost. Close coöperation between industries and regulatory agencies is necessary to achieve lasting results. The State Water Commission has carried out a great amount of research work in the industrial-wastes treatment field and improvements are in progress.

Stream Classification and Water Analyses

It is obviously impracticable and uneconomic to attempt to return all bodies of water to their state of pristine purity. The degree of treatment necessary in each location depends on the use to which the receiving body of water can be put and is to be put in the future. With this in mind, the State Department of Health and the State Water Commission have worked out a preliminary program of stream classification according to the highest use. Also, discussions have been held with all of the state sanitary engineers of the New England states with a view to classification of intra- and inter-state streams in the New England area, as may develop from other discussions this

morning. Some waters may be used for potable water supply, others for bathing, others for shellfish culture, others for boating, others for fishing, others for industrial purposes and others for navigation only.

Extensive sampling of shore waters has recently been done by the State Department of Health. In the summer of 1945 and 1946, samples have been collected for bacteriological analysis along our entire shore, in 2 to 6 ft of water on four stages of the tide at 1,000-foot intervals. On our inland streams the State Water Commission has this year resumed an extensive program of collection of water samples for analysis in the laboratories of the State Department of Health.

Conclusion

In Connecticut, great progress is being made in the field of municipal sewage treatment. It is expected that soon all sewage from municipal sewerage systems will be treated. Industrial-waste pollution creates a serious problem and work is going on actively in this field to effect improvement. In connection with all proposed structures to abate sewage and industrial-waste pollution, competition for materials that are now needed in many fields, such as housing, together with high and uncertain costs have tended to slow down construction but as soon as conditions become more stable, it is expected that rapid progress will be made.

We believe that the compact method affords the states an opportunity for dealing with pollution of waters which is highly preferable to outright Federal control. We are of the opinion that proposed Federal legislation providing for State and Federal coöperation in pollution abatement with a certain amount of Federal guidance and stimulation is a better means of obtaining the desired goal from both State and National viewpoints than other proposed legislation calling for drastic Federal action. The states must, however, assume their responsibilities if Federal control is to be avoided.

THE ACTIVITIES OF THE STATE SANITARY WATER BOARD IN MAINE

BY J. ELLIOTT HALE*

[*Read September 19, 1946.*]

THE State Sanitary Water Board was first organized by the Legislature of 1941 for the purpose of controlling, preventing and abating pollution of the waters of the state. In 1945 this law was amended so that all new industries established after July 24, 1945, would require a license to discharge industrial wastes into the receiving body of water. Existing industries could continue to discharge their load of pollution into the waterways of the state. Prior to the establishment of the board, very little had been done on a statewide basis to abate or prevent the pollution of our rivers and streams. Although laws were passed to abate and control local pollution by sawdust, etc., from the many sawmills that flourished at that time, these laws were repealed at a later date after the passing of the sawmill. At present there are about 20 private and special laws for the protection of public water supplies and similar health measures.

These previous laws precipitated some very interesting law suits. The Maine Law Court decision of 1885 in the case of the Lockwood Company, Waterville, vs. firms above the mill depositing sawdust and slabs into the Kennebec River is of great importance in this respect. This decision reads in part: "Every proprietor upon a natural stream is entitled to a reasonable use and enjoyment of such stream as it flows through or along his own land, taking in consideration a like reasonable use of such stream by all other proprietors above or below him. The rights of the owners are not absolute but qualified and each party must exercise his own reasonable use with a just regard to the like reasonable use by all others who may be affected by his acts." This same reasoning applies today in the work of the Sanitary Water Board.

The revival of stream-pollution control and abatement was predi-

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cated upon the intolerable condition of the Androscoggin River in 1940 and 1941. From 1941 to 1945 very little work was done because of a lack of funds but, with a change in the law and an appropriation of $10,000 for each of several years after 1945, the activity was greatly increased. An additional $3,000 was made available for the purchase and outfitting of a mobile trailer for field work. With this money and a trailer we were greatly encouraged in our efforts but we still lacked any real authority to abate existing conditions.

The function of the Sanitary Water Board is to study and investigate the conditions of the rivers and streams of the state, to classify the same as to present use and to recommend ways and means for their improvement. To this end a program of study and classification of all of the inland and coastal waters has been inaugurated. To date we have surveyed approximately 6,000 miles of inland waters, principally in the southern, western and central parts of the state. These waterways have been classified as A, B, C or D, according to present use. This classification is tentative and awaits confirmation by the Board. It corresponds very closely to the classification adopted by the New England Conference of State Sanitary Engineers during meetings in 1945.

After a watershed has been surveyed and classified, every effort is made to have the towns and cities and the industries adopt methods for abating their share of the pollution. By using this method we have been fairly successful in at least one river basin.

In the case of industry, much research has been done to find a satisfactory by-product from the individual wastes; this has been particularly true of the canners and pulp and paper units and more lately of the starch industry. The treatment of sewage has been fairly well established, although some changes have been made during the past few years because of experiments and research by members of the armed forces. Every effort has been made to make such information available to towns and cities requesting the same.

We have endeavored to publicize the work of the Board by speaking at civic and fish-and-game clubs and through articles in state magazines and papers. It is anticipated that more emphasis will be placed on this phase of the work during the coming year.

The New Hampshire Stream Pollution Board has been estab-

lished on an advisory basis and it is expected that some work will be done with them on our interstate rivers, especially the Piscataqua and Salmon Falls Rivers, and in the Great Bay area at Portsmouth and Kittery. The tributaries to the Saco River and portions of the Androscoggin River will also need attention by the joint boards.

The existing law allows the Board to coöperate with other states and with the Federal government for the purpose of carrying out the provisions of the law relative to interstate waterways.

The information secured by the Board to date has been made available to the Maine Salmon Fisheries Commission, which was established by the 1945 Legislature. The Board has also coöperated with the State Department of Inland Fisheries and Game on pollution studies and with the Conference of the New England State Sanitary Engineers, especially on a uniform system of stream classification for our New England waterways and on pending Federal legislation.

During the past summer the Board has been engaged in making a survey of the coastal waters from Kittery to Cape Elizabeth, covering about 1/6 of the total coast line of 2,500 miles. The results have indicated that there is a very definite increase in the pollution of these waterways by our summer population. At present we are working in coöperation with the State Departments of Agriculture and of Sea and Shore Fisheries in making a resurvey of the 58 closed clam-digging areas along the coast. It is anticipated that this survey will take about 3 months.

On checking the information covering the water basins surveyed to date, we find that we have classified about 6,000 miles of our rivers and streams. Of this mileage, only 60 are Class D, 89 Class C and the rest A and B. One hundred twenty-eight industries were found that contributed wastes, equivalent to the raw sewage from about 160,000 persons. There were 314,000 persons on the watersheds surveyed that contributed about 196,000 gal of treated sewage and 5 mil gal of untreated sewage to the various rivers and streams in the basins. These results further indicate that much of the pollution is localized and can be reduced by primary treatment of the sewage and industrial wastes.

It is anticipated that surveys will be made of additional rivers, streams and coastal waters during the coming year. The availability

of men and materials and the cost of the same will be a very important factor as to whether or not public sewers and sewage disposal plants will be constructed or whether industrial plants will provide facilities for treating their wastes. More contacts will be made to encourage such construction and research will be fostered to help eliminate the pollution from our rivers and streams.

There is need of more definite and stronger legislation that will eliminate the pollution from our waterways; such legislation must be firm in purpose but not drastic enough to cause hardship to our industries and to our towns and cities.

No person or group of persons should be allowed to exploit or damage these natural resources at the expense or detriment of another person or group of persons. The waterways of this state are for the many and not for a chosen few.

PROBLEMS AND PROGRESS IN HANDLING STREAM-POLLUTION ABATEMENT IN NEW HAMPSHIRE

BY LEONARD W. TRAGER*

[*Read September 19, 1946.*]

IN THE early period of our history, when our cities and towns were small and sparsely located, our streams with their natural purification forces did a remarkable job in serving us but, as these places grew in size and industrial centers became more frequent, the load on some of these streams, at times, became too great for them to carry. Modern living now calls for bathrooms with flush toilets in all homes. Modern living also calls for an endless number of processed foods and materials. All these things create additional loads in streams, because the waste products are discharged into them. Continued demands by the people for new things will continue to make our streams worse as time goes along.

If our streams, lakes and tidal waters had no other use than to transport wastes away from the points of discharge, the problem of use, management and correction would not be so difficult. However, that is not the case. Instead, our surface waters are used for many purposes and by almost everyone in the state. For some uses a high quality of water is demanded, while in others the only thing desired is the transportation of wastes by the streams. Between these two extremes the quality demanded for recreational purposes, fish culture and industry varies greatly. With these varied interests there are bound to be conflicts as to which interest should have priority. It should be obvious, particularly to the members of this organization, that public water-supply uses should have the highest priority. It should also be obvious that every other interest must be considered to have a priority which will be consistent with the best interests of the state. The reasons for the conflicts in the past, therefore, have hinged not on what was best for the state but on what has been best for the particular parties concerned. In other words, each

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of these special-interest groups, finding themselves in conflict with other users, was always working to better its position, disregarding the rights and privileges of others. When these conflicts arose, it was only natural that the groups so involved would turn to the various state departments, who were asked to sit in as referees. The State Department of Health has been forced into this position many times in the past and, in most of the cases, the immediate solution was not always forthcoming, due in some part to the inadequacy of state laws.

Because New Hampshire has two large industrial groups—*i.e.*, the recreational industry and manufacturing—each demanding different uses of the waters, and because our surface waters are one of this state's greatest assets, Governor Charles M. Dale found it advisable to set up a special organization for the study of this complex problem of surface-water uses. In order to make this new organization, that of the New Hampshire Water Pollution Board, one that would be representative of all water interests, members were chosen as follows:

(1) The State Health Officer as chairman;
(2) The Governor or his representative;
(3) The Director of Recreation of the Forestry and Recreation Department;
(4) Two representatives from industry;
(5) The Director, State Planning and Development Commission;
(6) A commissioner from the State Public Service Commission;
(7) The biologist of the State Fish and Game Department;
(8) The Director of the State Water Resources Board;
(9) A representative for municipalities and the water-works industry;
(10) The Director, Division of Sanitary Engineering, of the State Department of Health, as Technical Secretary.

The man selected to represent municipalities and the water-works industry was Harry Manson, Superintendent of the Lebanon Water Works.

In New Hampshire, as in almost all other states, there are groups who are convinced that no sewage or waste products should be discharged into any stream. These groups obviously are not fully aware of all the various aspects of the problem nor what the terms "sewage and industrial-waste treatment" mean. If, however, these groups studied the problem, then they would recognize the fact that to bring all our lakes, streams and tidal waters back to their pristine

purity would mean that no sewage or wastes of any kind, except those completely purified, could be discharged. To accomplish this, every city and town would have to install sewage-treatment plants that would give complete treatment to the sewage. This in turn would be reflected in the tax rate of those cities and towns. Similarly, every manufacturing plant would also have to install treatment plants and other similar facilities. At the present time, there is no known economical type of treatment for some industrial wastes and, because of this, any order allowing for an outright prohibition of waste discharges into surface waters would mean a forced close-down of those plants forevermore. In other types of industries, the manufacturing processes are such that they produce extremely high organic and other oxygen-consuming wastes which, when discharged in large quantities into the streams, place extreme loads upon them. To treat these wastes completely would mean excessive costs to the manufacturer, which in turn would be reflected in the selling price of the manufactured goods and would be ultimately paid by the people. From this brief description it can be seen that

(1) to treat all manufacturing wastes to such a degree that the final plant effluent would not bring the stream waters below their so-called pristine purity is impossible;
(2) that the cost of treatment for some types of wastes is prohibitive, and
(3) that the costs of manufacturing-waste treatment would, in some cases, be reflected in increased costs of the manufactured goods.

On the other side of the picture there are lakes, streams and certain tidal waters which, because of their location, popularity and use, appear to have an obviously greater use recreationally than for any other purpose. On such bodies of water, people have constructed camps, summer homes and even permanent dwellings, which have increased the property valuation for the towns so located. These people have spent considerable sums of money just for the privilege of living on or near these supposedly clean waters. From this building, combined with the revenue derived by having these people as summer or full-time residents, both the community and the state have benefited. Most of these bodies of water have an area greater than 20 acres and, therefore, they are classified as public waters or "great ponds". Being great ponds they are state waters—that is, they

are property of the state and not property of individuals or groups. Therefore, because these bodies are property of the state and because it can be shown that these waters have a greater value recreationally than for any other use, they should be set aside, classified and protected for that particular purpose.

In regard to public waters or great ponds, it is interesting to note what is contained in our statutes. Section 17, chapter 182 of the Revised Laws reads as follows:

> "17. Area. All natural bodies of fresh water having an area of twenty acres or more are public waters, and are held in trust by the state for public use; and no corporation or individual shall have or exercise in any such body of water any rights or privilege not common to all citizens of this state.
>
> "18. Smaller Ponds. Nothing herein contained shall be construed as an abandonment or waiver of any right of the state in fresh water ponds containing between ten and twenty acres."

Still another aspect of water uses is that in regard to public health. In many cases water supplies are derived from surface sources, which naturally should be kept free from contamination. Yet the State Department of Health is almost continually in conflict with other water users or prospective users. Among these are the fish and sporting interests, some of whom demand the right to use all watersheds, even though they are public water supplies. Other recreational interests demand boating and bathing in these public water-supply streams and lakes.

In some cases where both domestic and industrial wastes are discharged into streams in quantities greater than the stream can take care of, public health nuisances have resulted. To correct these nuisances the State Department of Health has almost always been forced to resort to court action. Such procedures are expensive and time-consuming. These facts are brought out simply to show that here again is another conflict as to water use.

From the above brief discussion relative to water uses and waste disposal, it should be obvious that the new Water Pollution Board appointed by the Governor and Council has a big and important job before it. The job set out for this newly appointed board can probably best be described in a statement of purposes and policies as follows:

PURPOSES AND POLICIES OF THE NEW HAMPSHIRE WATER POLLUTION BOARD

(1) To make technical investigations and surveys which will include analytical data relative to pollution on all streams, lakes and tidal waters.
(2) To adopt standards for classification of waters.
(3) To classify streams, lakes and tidal waters (a) according to present highest use (present condition and use) and (b) according to potential highest use, being mindful of the industrial, economic, geographical and social factors.
(4) To confer with neighboring state officials, committees or water pollution boards for the purpose of discussion on matters affecting pollution of interstate waters.
(5) To consider the feasibility of interstate compacts and to recommend the development of such interstate compacts, if deemed necessary.
(6) To give directions for the conduct of all work involved in the making of surveys and investigations on stream pollution, including the expenditure of funds.
(7) To make periodic reports to the Governor and Council as to findings with recommendations.

In order to make the above-mentioned technical investigations and surveys, a mobile laboratory with two chemical engineers is being utilized. This procedure, along with the data so collected, will, of itself, indicate the present classification or highest use of a particular body of water. By a study of these and other data, the board can then classify the body of water in question according to its future or potential highest use, being mindful while making these studies of the industrial, economic, geographical and social factors involved.

In the eastern section of New Hampshire, considerable interest has been shown in regard to a particularly large body of water. It is known that these waters are polluted and that the present value as a recreational area is limited. Studies have been made, which show what could be done in this area recreationally, but in the conclusions on the report of these studies a statement is made to the effect that whatever change is made is dependent upon the treatment of sewage and wastes discharged into the tributary streams.

Because the problem of what to do with this large body of water has been a most difficult one and because it affects so many people and has so many conflicting interests, the Water Pollution Board has elected to make this area and its tributaries the first study problem. As stated above, there are many conflicting interests. These include the following:

(1) Fishing interests;
(2) An adjoining state, because of the streams in that state discharging into rivers tributary;
(3) The twelve cities and towns in New Hampshire which discharge sewage into streams tributary to this large body of water;
(4) Manufacturing interests, which include the following:
Machine and tool factories, button works, textile (wool and cotton) factories, shoe plants, tanneries, bleacheries, alcohol plants, furniture factories, paper and paper-board mills.

To make this picture clearer and to show how complex this particular problem is, let us say that it was decided that this body of water should have a future or potential classification such that the waters discharging into it would produce waters meeting bathing-water standards. Then, to do this may mean:

(a) The development and passage of compacts between the two states involved, along with the Federal government, because it also is involved;
(b) The installation of sewage-treatment plants for the twelve cities and towns mentioned above;
(c) The installation of industrial-waste treatment plants for some of the industries.

Those of us who are acquainted with the state know that the problem with regard to this particular body of water is not the only one that the New Hampshire Water Pollution Board will have to study and report upon. Actually, the board has been directed by the Governor and Council to classify all surface waters in the state. When this is done and if laws are passed giving the state power to carry out all the functions associated with present and potential classification, then the chaos of stream and water uses now existing will disappear. Then everyone will know what bodies of water are set aside for public water supplies, for bathing, boating and fishing, for industrial supplies and for the transportation of waste without nuisance.

In most cases, the value of our surface waters cannot be stated in exact terms but it can be said that, without maintaining these waters in a condition according to their potentially highest use, progress in the state will be definitely retarded. By the action of the Governor and Council in the appointment of an organization to study this extremely important natural asset—that of all surface waters—continued progress for the state, in so far as these things are concerned, will be assured.

PROBLEMS AND PROGRESS IN HANDLING STREAM-POLLUTION ABATEMENT IN VERMONT

BY EDWARD L. TRACY*

[*Read September 19, 1946.*]

LAWS to control stream pollution in Vermont are very incomplete and inadequate. Streams, ponds and lakes used as a source of water supply are protected by a law that prohibits the discharge of sewage or polluting matters into such waters. This law cannot be used to interfere with the agricultural use of land and sewage from a municipality or public institution is exempt from control.

A few lakes and portions of streams are well protected by specific statutes, which apply only to the waters named.

Fortunately, the streams from which public water supplies are taken do not in any case receive sewage above the water-supply intake. Lake Champlain is the only body of water, contaminated by sewage, from which water is taken for domestic use after proper treatment.

Stream-pollution control and abatement promotion in Vermont cannot, therefore, use the strong public-health argument of safer water supplies. General improvement of public health protection and improvement of recreational facilities are the strongest arguments in favor of pollution control at present.

The classification of streams according to present and expected future use is being done according to the tentative standards adopted by the New England state sanitary engineers. The Connecticut River is the only stream in which several other states are jointly interested. The Hoosick River is in Vermont, Massachusetts and New York, while the Deerfield River is in Vermont and Massachusetts. All other streams are entirely within Vermont or of joint interest to New York or the Province of Quebec.

The state has been conducting an educational and promotional campaign since last January, to acquaint the people in general and

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the members of the State Legislature in particular with the need for stream-pollution control and the proper state laws which must be enacted.

Each major river basin, of which there are twelve, in the state is being organized so that pollution control and sewage treatment can be planned for the particular needs of each basin. This is in line with the general plan of stream classification for New England.

To organize a river basin, the State Chamber of Commerce and the State Department of Public Health organize a mass meeting in a central place or in the largest municipality in the river basin. At this meeting a river-basin committee or sanitary council is organized, with representatives from all towns. Meetings are then held in other municipalities in that river basin, in order to reach all possible people, public officials and legislators. The State Chamber of Commerce has been very successful in organizing these meetings. With the aid of the local chamber or service clubs, the State Chamber is an excellent medium for bringing together people interested in public health, industry, recreation, fish and game, and agriculture. The film "Clean Waters" is owned by the State Public Health Department and has been used at practically all meetings.

A state legislative committee was formed, to draft proposed laws to control stream pollution. The first law to be prepared is a sewer service-charge enabling act. At present, only one city, Burlington, has authority to make service or rental charges to finance revenue bonds for sewage-treatment plant construction. The proposed law, just written by the committee, will be discussed at a meeting of representatives of all river basins at Montpelier on Sept. 20, 1946. It is doubtful if mandatory pollution-control legislation will be submitted to the next Legislature. The last attempt was in 1943, when the State Department of Conservation introduced a law, which was so amended before passage that it practically legalized pollution instead of preventing it. The Conservation Department is responsible for the enforcement of this law.

An attempt at this time to have a similar law, prohibiting pollution, passed would be almost certain to receive similar treatment. Members and prospective members of the State Legislature who have been contacted do favor permissive legislation, such as the en-

abling act. It is most likely that such legislation will be enacted first, to be followed by proper control legislation after a reasonable start has been made throughout the state to clean up streams and lakes, by installing sewage-treatment plants in the larger cities and villages.

The need for sewage treatment in Vermont is not denied by anyone. Sewage-treatment plants serve only 10,500 people—6% of the sewered population or 2.9% of the total population of the state. The average for the United States is about 59% of the sewered population or 32% of the total population. It is hoped and expected that the present work of promotion will create enough interest actually to bring about the construction of sewage-treatment plants. At present Burlington, Brattleboro, Springfield and Brandon have plans completed or nearly so. Other communities have plans that are being reviewed.

PROBLEMS AND PROGRESS IN HANDLING STREAM-POLLUTION ABATEMENT IN RHODE ISLAND

BY WALTER J. SHEA*

[*Read September 19, 1946.*]

RHODE ISLAND was one of the first states to adopt a law to deal with the pollution problem in a comprehensive manner. As early as 1904 a law was adopted to prevent the pollution of the sources of public drinking-water supply. Laws were also adopted early to control pollution of shellfish grounds. It was not until 1920, however, that a law was enacted to control pollution of any of the waters of the state, if such pollution caused damage. It is claimed that the frequent occurrence of oil pollution in Narragansett Bay, which accompanied the great expansion of Providence Harbor as a terminal for oil tankers, was an important consideration in bringing about the adoption of the pollution law of 1920.

The pollution law was originally administered by an independent board of three members. In 1935, through a reorganization of the state government, its administration was transferred to a separate division within the Department of Health. In 1939, as the result of a second reorganization, administration of the law came to the Division of Sanitary Engineering and has remained there.

During the 26 years that the pollution law has been in effect, the number of municipal sewage-treatment plants has increased from three to ten and one of the three already in operation in 1920 has undergone major renovation. At the present time the sewage of nearly 90% of the sewered population of the state receives treatment. A large number of industrial-waste treatment plants has been constructed. It is estimated, however, that only about 10% of the industrial wastes which do not reach city sewers are treated.

Despite this considerable accomplishment, much remains to be done in pollution abatement in Rhode Island. A large part of the

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sewage of two Rhode Island cities receives no treatment whatever. The adoption of waste-treatment facilities by industry has not kept pace with such action by municipalities. Some existing municipal treatment plants do not provide the degree of purification demanded by the receiving stream.

Any pollution-abatement program is beset with many obstacles. There is, first of all, the tendency of a large part of the public to accept as a normal state of affairs rivers which have been polluted for a long period of time. Municipal officials are, in many instances, reluctant to make large investments for the construction and maintenance of sewage-treatment facilities, when the benefits therefrom accrue largely to the communities downstream. Other improvements, such as the relief of highway-traffic congestion, better recreational facilities, etc., are urgently demanded and generally take precedence over sewage treatment. Where economy and sound engineering point to the need of two or more communities' joining in the construction of a single treatment plant to serve all concerned, it has been extremely difficult to obtain voluntary joint action and this has frequently been the cause, or excuse, for no action by any one of the communities concerned. In some instances, the sanitary disposal of industrial wastes must wait upon the installation of sewage-disposal facilities by a municipality.

The treatment of wastes by industry has been rather easy to obtain in cases where some product of value could be recovered. Unfortunately, most of the industrial wastes produced in Rhode Island are of a kind which yield no such products and they are not even susceptible of adequate treatment by the ordinary sewage-treatment plant. Successful treatment of such wastes requires more stages of treatment than are used for sanitary sewage and the expense of such plants is correspondingly great. Some industrial plants are so located that space is not available for treatment facilities.

It may sound strange but I can cite an instance of an unsewered community, which installed sewers and a modern sewage-treatment plant and, because of failure of the plant to handle industrial wastes successfully, an offensive condition was created, which did not exist previously.

What, then, can be done to overcome some of the difficulties?

First of all, if a pollution law is to be enforced, a municipality must have available the means of financing sewage-disposal improvements. It is doubtful that the court will order municipal officials to do the impossible or that which is illegal. This points to the need of a state law, permitting municipalities to assess sewer charges on an annual basis, to finance the construction and maintenance of sewage-treatment plants. Despite the objection of some experts on municipal finance, funds so collected should be set aside for exclusive use of the sewer department. Otherwise, poor operation is likely to result, as the sewer department in most communities fares poorly when it competes with other municipal departments for a share of the general tax fund.

Secondly, where economy and sound engineering point to a district treatment plant rather than several individual sewage-disposal plants, it appears to me to be the obligation of the pollution enforcement agency to exhaust every available means to have such districts created by the state legislature, rather than to order the installation of several individual sewage-treatment plants.

Thirdly, there must be close coöperation between different States on the same watershed in pollution abatement. The New England States are working along these lines at the present time, aiming at the adoption of interstate compacts for pollution control.

Finally, there is a great need for more intensive research on the treatment of industrial wastes, to devise cheaper means. It is felt that such a need can be met most economically by the Federal government.

PROBLEMS AND PROGRESS IN HANDLING STREAM-POLLUTION ABATEMENT IN MASSACHUSETTS

BY ARTHUR D. WESTON*

[*Read September 19, 1946.*]

WARREN J. SCOTT, Director of the Bureau of Sanitary Engineering of the Department of Health of the State of Connecticut, has told you of the ground-work of a committee of the New England Regional Planning Commission in the matter of stream classification and the coöperative action of the State Sanitary Engineers of the various New England States toward obtaining an agreed classification program of the streams in these states. Relative to the latter, the work of the Division of Sanitary Engineering of the Massachusetts Department of Public Health probably has differed but little from that of the other Divisions of Sanitary Engineering of the State Departments of Health in New England and of the state agencies having jurisdiction in the matter of stream-pollution control, except for the fact that the Massachusetts Department of Public Health, under an Act of the Legislature of 1945—*viz.* Chapter 615 of the Acts of 1945—now has mandatory powers in matters of stream-pollution control. This Act provides that the Department of Public Health

"shall from time to time, . . . subject to the approval of the governor and council, prescribe and establish rules and regulations to prevent pollution or contamination of any or all of the lakes, ponds, streams, tidal waters and flats within the commonwealth or of the tributaries of such tidal waters and flats; . . ."

Such rules and regulations were prescribed by the Department of Public Health on August 14, 1945, and were approved by the Governor and Council on September 19, 1945. These rules and regulations provide that no sewage and no human excrement, or compost containing human excrement, and no house slops, sink wastes or waste water, which has been used for washing or cooking, or other polluted water and no garbage, manure or other putrescible matter whatsoever

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and no manufacturing refuse, or waste product, or polluting liquid, or other substance which by itself or in combination with other substances is of a nature poisonous or injurious either to human beings or animals, or any putrescible organic matter whatsoever from a tannery, currying shop or other establishment or place where the skin, wool, hair or fur of any animal is treated, or from a slaughterhouse or other building for carrying on the business of slaughtering cattle, sheep or other animals, and no wastes from a melting or rendering establishment

". . . shall be discharged or put into any lake, pond, stream, tidal water and flat within the Commonwealth, or a tributary of such tidal water and flat, in a manner which may be injurious to the public health, or may tend to create a public nuisance, except as may be approved by the Department of Public Health when in the opinion of the said Department the best practicable and reasonably available means to render harmless such refuse, waste product, polluting liquid, substance, putrescible organic matter, or wastes have been provided in accordance with plans approved by the Department."

In accordance with this authorization, the Massachusetts Department of Public Health has, during the past year, referred to the office of the Attorney General information indicating violations of these rules and regulations by four different municipalities and several industries and the Attorney General is prosecuting in court, at the present time, cases against these municipalities and industries.

It has been the opinion of the Division of Sanitary Engineering of the Department of Public Health that the most important pollution to control is that resulting from the discharge of domestic sewage, because this type of pollution may more vitally affect the public health, as well as result in a nuisance, and it is the opinion of the writer that the public-health-program aspect of stream-pollution control has not in the past been sufficiently emphasized.

The classification system, referred to by Mr. Scott and with which the Division of Sanitary Engineering of the Massachusetts Department of Public Health concurs, does consider the public-health aspect sufficiently, as that classification takes into consideration the bacterial condition of the water, as well as the oxygen conditions and the relation of the oxygen conditions to the discharge of putrescible matter.

You will remember that Mr. Scott has indicated four types of waters, *viz*:

"Class A—Drinking-water sources or waters used for growth of market shellfish.
Class B—Waters used for bathing.
Class C—Waters used for recreational boating, fishing, seed oyster culture, or industrial supply after treatment.
Class D—Waters used primarily for navigation or transportation of wastes without nuisance."

In connection with the first two of these types, bacterial limits are placed on the waters. For example, the bacterial quality of Class A waters must be better than 50 coliform organisms per 100 ml, while that of Class B waters must be better than 1,000 coliform organisms per 100 ml. It is the opinion of the speaker that a sufficient amount of emphasis in the past has not been placed on sewage and industrial-waste treatment to maintain satisfactory bacterial conditions in the receiving waters. The emphasis has generally been in connection with works to reduce the organic load.

The classification proposed by the sub-committee of the National Resources Commission indicated that large rivers draining watersheds of large cities would appear ordinarily to fall in "Class C", although in some cases in "Class D", and that inland streams now receiving considerable volumes of sewage but not main carriers of waste may fall into "Class C", while inland streams draining sparsely populated areas would fall into "Class A" or "Class B".

It is the experience of our Division of Sanitary Engineering that there is a popular demand for the use of many streams and tidal waters for bathing purposes, where the bacterial condition of the waters may not always fall within "Class B", because the coliform bacterial density of the water is at times in excess of 1,000 coliform per 100 ml. These waters may have no difficulty in oxygen depletion and may be comparatively free from sleek or visible sewage solids and industrial wastes. As an example of this type of stream, your attention is called to a certain stream in Massachusetts (not interstate) which we will refer to as "Stream A". The bacterial examinations of samples of water collected from this stream over a period of three years, at a station where the stream discharges into a large recreational

basin, show a geometric average of only about 263 coliforms per 100 ml of water and a biochemical oxygen demand of about 2.8 ppm, the latter being not greatly in excess of the normal for that stream. The results of the examinations of the samples collected from the basin, however, show a geometric average coliform density of 537 and samples on occasion have shown a coliform density as high as 100,000 per 100 ml, while numerous samples showed as high as 10,000. During this same period the biochemical oxygen demand of the water of the basin has not averaged over 4.33 ppm. This stream is used to a very considerable extent for recreational purposes but, because of the occasional high bacterial counts of coliforms and pollution by mingled storm water and sewage, it has become almost an annual practice of the Massachusetts Department of Public Health to recommend that the beaches on this basin be closed for bathing.

Another stream in Massachusetts, which we will call "Stream B" and which is considered one of the streams most free from pollution, has shown on occasion a coliform bacterial density as great as 10,000 per 100 ml. This bacterial condition is attributed to the existence of outlets of unapproved sewers in villages along this stream, the existence of which is probably not known even to the voters in the municipalities in question. It is obvious that chlorination of the sewage as discharged from these outlets should be provided, even though there may be no need of other extensive sewage-treatment works.

In carrying out any work in matters of the classification of streams, it has been interesting to note the ability of certain streams to care for a considerable amount of pollution and maintain an oxygen balance throughout most of their course. Such a stream will be referred to as "Stream C". Between the upper and lower sampling points, this stream receives a considerable amount of sewage pollution and industrial waste. At its upper station, it has a drainage area of about 4,029 sq mi and a dry-weather flow of about 1,672 cfs or 1,080 mgd. It receives above this upper station large quantities of industrial wastes and domestic sewage pollution from upwards of 150,000 persons. Over a period of five years, when samples were collected nearly every month for biochemical oxygen demand and bacterial examinations, this stream at this upper station had an aver-

age biochemical oxygen demand of 2.9 ppm and a coliform density of 2,460 per 100 ml. The slope of the river from this sampling point to the lowest sampling station is approximately 1.15 ft per mile. At the next lower sampling station, which is about 18½ miles below the upper station, the drainage area comprises about 4,663 sq mi and the dry-weather flow is about 1,936 cfs or 1,250 mgd. The results of the analyses and bacterial examinations of samples of water collected at this middle station, over the same period referred to in connection with the upper station, show that there was an average biochemical oxygen demand of the river water of 13.9 ppm, while the geometric average of coliform density was 64,900 per 100 ml. At the lower station, a distance of 25 miles below the middle station, the drainage area comprises about 4,997 sq mi and the dry-weather flow is about 2,073 cfs or 1,330 mgd. The biochemical oxygen demand of the water at this lower station has averaged over the same period about 3.9 ppm and the coliform density has averaged 2,240 per 100 ml. Between the upper and the lower sampling stations, this stream received domestic sewage from approximately 425,000 persons, together with large quantities of industrial wastes, but in spite of this pollution, the stream in its course between the middle station and the lower station—a distance of about 25 miles—had recovered to practically the same condition found in the stream 18 miles above the middle sampling point. In connection with this stream, studies are being made at the present time with a view to providing district or municipal sewerage and sewage-disposal works.

Another stream in Massachusetts, which receives a very large amount of domestic sewage and industrial-waste pollution and which we will refer to as "Stream D", is one which, because of municipal sewage pollution, the Massachusetts Department of Public Health has been obliged to refer to the office of the Attorney General for action. This stream, at a point where the drainage area comprises about 72 sq mi, has been receiving raw sewage at times and for a number of months the discharge of sewage subject only to Imhoff-tank treatment. Because of the particular authority of the Department of Public Health in this case, the Division of Sanitary Engineering of the Department has, over a number of months, collected samples at frequent intervals at various points on the stream. The

results of these analyses have shown a biochemical oxygen demand of the stream above the point of discharge of the municipal sewage works of about 10 ppm, due to the discharge of industrial wastes into the stream above the main sewer outlet of the city. This point is only approximately 25 miles above the lowest sampling point of the stream. The discharge of the domestic sewage of the city has increased this biochemical oxygen demand to an amount between 20 and 30 ppm and the coliform bacterial density from about 1,000 coliform per 100 ml to 10,000,000 per 100 ml. In the course of the stream to the lowest sampling point, where it receives additional domestic sewage and industrial-waste pollution, the coliform density is reduced to 1,000 per 100 ml and the biochemical oxygen demand to less than 10 ppm, or about the same condition as the stream above the point of discharge of the municipality in question. This stream below the point of discharge of the municipality under investigation has a slope of approximately one foot per mile.

In connection with a certain interstate stream, which we will refer to as "Stream E", the results of our analyses show the interesting fact that, while this stream, over a period of years, has entered the state of Massachusetts with a biochemical oxygen demand of 2.2 ppm, this biochemical oxygen demand has been reduced to 1.53 ppm as it leaves the state, although in its course through the state it has received considerable quantities of industrial-waste and domestic-sewage pollution. However, the geometric average of coliform density shows that the coliform density of the stream has not averaged in excess of 714 per 100 ml as it enters the state, while, as it leaves the state, its coliform density has approximated 4,750 per 100 ml, indicating the necessity of chlorination in connection with the sewage treatment.

Another stream, which we will refer to as "Stream F" and which has its origin in Massachusetts and an outlet in a neighboring state, has a natural biochemical oxygen demand of about 1.75 ppm above all sources of pollution and a biochemical oxygen demand of 2.04 ppm as it leaves the state. The coliform density in this case was reduced from 47.5 per 100 ml to 39.8 in its passage through the state. This condition was believed to be brought about by certain industrial wastes, which had a sterilizing effect on the bacteria in the stream.

Another stream, which will be referred to as "Stream G", also has its origin in Massachusetts and its outlet in a neighboring state. This stream receives considerable amounts of industrial wastes and domestic sewage. Its natural biochemical oxygen demand of about 1.2 ppm was increased only to about 5.6 ppm in its passage through the state, while the bacterial content of the stream was increased from 832 per 100 ml to 126,000 per 100 ml. This condition is chiefly due to absence of chlorination of the effluent from a certain, large, partial sewage-treatment works. Chlorination of the effluent from these works should be provided.

The writer believes that Massachusetts must claim the distinction of having one of the most, if not the most, highly polluted streams known. This stream will be referred to as "Stream H". Over the period of the last nine years, this stream in its industrialized course has shown a biochemical oxygen demand, on an average, from 4.1 ppm to 787 ppm, with an occasional sample in excess of 1,000 ppm and one showing 1,420 ppm. This stream has a drainage area at its mouth of only about 12 sq mi and receives the overflow of large quantities of industrial wastes mingled with domestic sewage. The bacterial condition of this water is not as bad as might be expected for such a high biochemical oxygen demand, because of the sterilizing effect of certain industrial wastes entering the sewerage system which overflows into the stream. We are pleased to report that remedial works have been designed and are about to be installed to improve conditions in this stream.

Considering the fact that Massachusetts is the third most densely populated state in the Union and the fact that many of its streams are highly industrialized, we can be reasonably proud of the condition of the streams as a whole. Much remains to be done in the matter of stream-pollution control and much progress has been made as a result of the mandatory powers given to the Department of Public Health by the Legislature of 1945.

It is the opinion of the speaker that the solution will not be through Federal legislation and, in appearing before a Congressional committee in connection with certain legislation proposed in matters of stream-pollution control, the speaker recommended that any Federal legislation in the beginning be limited to research and fact-

finding and that no mandatory powers should be given the Federal authorities at this time. The experience of the Massachusetts Department of Public Health, more especially at its Lawrence Experiment Station, has shown the necessity of careful investigation and research before the exercise of police power. From 1887 to 1945 the Massachusetts Department of Public Health had no mandatory powers in stream-pollution control, except in connection with five streams and certain tidal waters. We feel that we now have the facts relating to most of the stream-pollution problems in the state and that we can therefore make concrete recommendations as to proper control. With these facts in hand, the Department of Public Health expects to be able to show very considerable improvement in the streams in our state over the next three years. Our Division of Sanitary Engineering appreciates the coöperation of the other New England States in the stream-classification program as set forth by Mr. Scott. We hope that this program will result in the adoption of stream-pollution compacts between certain of the New England States, in order to make the control more effective. The Commonwealth of Massachusetts, through its State Planning Board, has legislative authority, under Chapter 278 of the Acts of 1936, to negotiate compacts for "the elimination of pollution".

POLICY CHOICES IN EMPLOYER-EMPLOYEE RELATIONS

BY ROYAL PARKINSON*

[*Read December 19, 1946.*]

IN TRYING to help you on this subject, I am not too sure of having selected the problems which give you concern. I thought I was familiar with almost every kind of industry but I confess that all I know about water works was taught me by the superintendent of the water company in my home town. But he doesn't have even a pump; he employs the law of gravity. At times, even that law seems to give him some worry.

One assumes that he finds little comfort in Jeff's experience, when Mutt asked him what it is that holds the Chinese upside down on the bottom of the earth. When Jeff told him that it is the law of gravity, Mutt wanted to know what they did before that law was passed.

Your Committee and I have done some estimating, therefore, as to what your problems may be.

Government vs. Private Employment

It is important first to clarify the difference, if any, between public employment and private industry. Some of the characteristics of public employment are inherent, some are legislated and some are acquired from private employment, by contagion.

This is equally true of private industry. Some of its human relations are inherent, some are legislated and some are indirectly Government-compelled.

Inherent in public employment, for instance, is slowness in adjustability to change and, when adjustments occur, they are mass adjustments, not to individual employees, as a rule. This is because the stockholders are many and, although they have a profit motive of a sort, it is in terms of many and varied individual self-interests, not money profit. Voters are, therefore, hard to marshal for an improve-

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ment, since uniformity of motive to appeal to is usually lacking. For instance, municipal utilities, I think, find it difficult to obtain money to invest in capacity for future growth, because the vision of the average voter doesn't encompass much of the future. Also, for instance, Government wages are set by wholesale and can be changed only by the voters. All this, of course, is because, in public enterprise, the customer is the stockholder. The voter, not necessarily the taxpayer, is the principal stockholder. Voters are governed largely at times by emotions but normally are responsible and sensible, if given full information. There are few long-term labor policies in Government enterprises as yet. Civil Service is one part of a Government labor or personnel policy. The Tennessee Valley Authority went farther and developed a complete personnel policy.

In 1912, Congress gave Federal employees the right to join or organize unions which do not impose an obligation to strike and gave them a right to seek legislation affecting their interests. You remember Calvin Coolidge's applying that "no-strike principle" to local government. But I don't know of any state or municipal legislation to this effect in New England. In any case, such laws are not effective in a time like the present. Strikes are proceeding in public occupations as in private.

In recent years, there has been great expansion in the number of Federal employees. They number more than 3,000,000 now. There are more of them in Massachusetts and some other states than there are state and local government employees. You can see that the difference between public and private employment has now become academic.

Government is now so far in the private business field that some of its enterprises employ more than any private concern. The Government is active in home building, hospital operation, electric power, life insurance, etc.

Strikes in any of a variety of private industries, such as milk, coal, elevators, trucking, newspapers, bus, railroad, telephone, and certainly water works, can injure the public welfare as much as in public employment. The truth is, our economy has become so complex that it has many bottlenecks. Almost any group can shut off the people's bread and butter. It is, therefore, more and more impor-

tant that these bottlenecks be kept open in the public interest by voluntary methods. For it is clear that Government compulsion and laws do not succeed.

Available Methods for Promoting Teamwork

In trying to protect the public interest in employer-employee relations, the most instant situation is that the National Government, while acting merely as referee among its own employees, has been playing on one of the teams in private industry. Its laws pertaining to private employment do not pertain also to public employment. . . . Social Security, the Wage and Hour Law, and the Wagner Act, for instance. The emphasis of the hour nationally is upon *getting* money, not upon *giving* value, upon more pay with less work, and upon the collective type of employer-employee relations. This, in turn, has become a policy of "might is right" in labor relations. Employees as well as employers and the public are victims more extensively than usual this year.

We have in private industry spectacular increases in wage rates, resulting in spectacular rise in costs and prices. Excessive rates are likely to lead to reduced *annual* income and to unemployment sooner or later. Meanwhile, the successful use of force in turn leads very naturally to Government employees' wanting their share and to their resorting to strikes in some cases. But these money raises are somewhat artificial and misleading, for, on the average, each member of the labor force in this country is already carrying a load of Government debt amounting to $4,500. With all the increases he isn't getting out of debt and may be getting into debt more deeply and more rapidly than employees in private industry, because the Government will probably go into more debt to pay increases.

Collective Bargaining Proving Itself No Panacea

The important thing to notice in all this picture is that the Government has found no universal way to interest employers and employees to work together in the public interest. With all the power of Government behind collective bargaining for a decade and with the necessity for the collective method in many situations, even today only about 25% of the American labor force is in unions. The

maximum union density was 45% in England in 1918. It fell to 25% there between wars and in this war rose to 38%. In the eight years *since* the Wagner Act there have been three times as many strikes as in the eight years preceding it and yet there are companies with as many as 5,000 employees, whom the unions have failed to interest and who have long been free from strikes.

Available Choices in the Interest of All Three Parties

The first step in our problem, therefore, is to recognize that there is still, and always will be, a choice between individual dealing and collective dealing and that, where there is collective dealing, there will still be need for a substantial degree of individual relations. For some departments may be in unions and others not, and employees may be in but foremen out.

The second step is to recognize that the wage relationship is not the only or the principal key to harmony. At least 55% of the long-term solution lies in the group of little, emotional types of incentives, which appeal to all people somewhat and to many people are controlling. No doubt you have observed that the unions which strike most and demand most are those whose workers are already the highest paid in the country.

Not only this but all the profits in America, as shown in the latest Government reports, if divided equally among the "labor force" of the country would add only 10% to wages. This increase would be for a year only, of course. Then, as employers began to close up, unemployment would come. In that year, however, those workers who obtained more than 10% would, of course, compel other workers to take less than 10%. These spectacular increases are not a favor to *all* workers and cannot long remain a favor to those who get them.

Collective Bargaining vs. Individual Dealing

Whether one uses an individual plow or a gang plow to till a field isn't important. Both kinds of plow can do the job. Each has some advantages and some disadvantages. For instance, the gang plow, when obstructed by a rock, stops six plows during repairs. The individual plow is not stopped. It doesn't have so much power and doesn't hit so hard as to break the plow and can ease around the

rocks. If a favorite flower bed or tree is in its path, the individual plow can spare it but the gang plow must ruthlessly uproot it. The gang plow costs more because it requires engine power rather than using horses, for it depends on force. On smooth land, it may be faster. On rough land the individual plow may be the faster. The gang plow will never find universal use. Neither kind of plow is a panacea for all conditions.

The important thing, in the public interest and in the interest of your members, is not the kind of plow but the kind of plowman. It is the type of human leadership which determines whether the result is progress or retrogression.

The Emotional or Non-Financial Incentives

Now let us explore the non-financial incentives a bit farther—the emotions to which wise management will appeal. Not the least among these is the little matter of deserved commendation from the boss not being overlooked. Another is fear of favoritism. Attaching the pay range to the job, not to the individual on it, solves this, if one lives up to it. Advancement in pay within those ranges on a merit basis, with the individual's progress systematically measured rather than dependent upon personal decisions by foremen, is the best course. This latter is usually thought to mean the squeaky wheel's getting the grease. Treatment of the worker as a self-respecting individual, having the same emotions and the same desire to be recognized as somebody different from the run-of-mine, as the boss has, is another incentive to which one can appeal. People, whether supervisors or subordinates, all have the same desire to grow—if not in pay, in community prestige, responsibility or respect from their employer or their fellow-workers. Again, many families want their young people to work where discipline is good; others want to work near home or where their friends work. Then, not only self-interest but a man's considerateness for his own family in its emergencies is a universal trait.

In 1932—at the bottom of the long depression—a drive to build a local hospital took two of us to the door of a big immigrant from southern Europe, soliciting contributions. He consulted his wife and together they gave $50.00, saying, "The poor people need a hospital

so they can visit their sick." We were invited into his home on the top floor of a six-tenement block. He was a semi-skilled worker in overalls, 25 years with his company. In his immaculately clean home we observed his five children around a piano, each with a toy musical instrument. He told us that he kept them home nights, learning American songs, because he wanted them to become Americans. He said he avoided drink, smoking and movies for their sake.

As we left, he asked without complaint when his company would have work for him. This startled us, for we didn't know he was not working. In answer to a question, he said he had been out three months and was to be sent for, when there was work. Inquiry of his foreman next day brought the highly dubious explanation that he had been laid off early, "because he had saved his money and those who had not might go on the town."

For the next job which opened in his company, its foreman requisitioned a young friend. The manager, however, required him to take this 25-year-service man. He did so but laid the man off a week later and avoided filling the job by giving other employees overtime.

The next job to open was janitor of office toilets—lower paid but steady, regardless of depressions. It was offered this 25-year man with apologies and with assurance that he would still be at the head of the line for other jobs, if he preferred. He took it.

A few weeks later, upon meeting him, I asked how the job was going. He said, "Fine. It's the best job I ever had." "Why do you say that, Mr. J.? Your regular job paid you $30.00 and this pays only $18.00," was my inquiry. His answer was this—"Yes, I know, but this job gives me a chance to see how nice people conduct themselves and I can teach my children." I tell you, wages are not the only incentive in the choice of an employer.

Eventually, all five children of this man entered the employ of this company, two of whose foremen had rejected him. Four of them are high-school graduates with honors. The other is a foreman. And so you see, also, that attention to the workers' families is a very important part of a successful personnel policy.

Foremen, too, are subject to all these appeals. They, too, are human. They have both emotions and pocketbooks. It is often their feeling that they are not being fairly treated by their manage-

ments which becomes contagious to their subordinates. Sympathy is not asked by workers. Employers should organize policies to marshal these non-financial incentives for the purpose of the business.

Both wage administration and "emotion administration," if we may call it that, are forms of leadership. The employer is in better position than unions to furnish that leadership, because he has jobs to offer and unions do not. But, whether employer or union, or both, furnish the essential leadership, it needs to be continuous, good leadership.

It is perfectly possible to organize employer leadership to be continuous and to be sensitive to the workers. These two kinds of administration constitute a personnel policy.

Develop a Company-wide Personnel Policy

To do so, the employer must start at the top, with his cabinet or his foremen, work out a plant-wide personnel policy, reduce it to writing and put it in the hands of both foremen and employees, office and factory. It should apply equally to supervisors and to workers. One can't have one policy for the one and a different one for the other. It should cover both a wage policy and an "emotion policy."

Then, it is important to assign the responsibility, to make sure that the policy is practiced continuously. As double insurance of this, he should set up a stated grievance procedure or "problem procedure." This gives the workers a chance to help insure the practice of the policy. It doesn't need to provide outside arbitration at the top always. Where there is a union, such an internal court will be compulsory. But it can be set up voluntarily without waiting for compulsion. It should be available both to employees and to foremen.

Sensitized Supervision

If the employer does not have a union and wants his leadership to make individual dealing work well enough to be acceptable to his workers, he will need what might be called "sensitized supervision." There are several ways of developing this with continuous, good leadership. A personnel director is not enough but can help greatly. A written policy, visible also in practice, is the key. The entire supervisory force needs to be enlisted.

The type of relations between management and foremen really determines the kind of relations between foremen and subordinates. Such relations, good or bad, are contagious. It is at the supervisory level that the employer should address and practice his personnel policy and concentrate his attention. He cannot expect to deal with his workers directly by contract or otherwise, leaving his foremen out, and have good labor relations. He must fan out his personnel policy through his supervisory force.

Leadership in employer-employee relations is in the supervisory force of business, whether it be public or private. These supervisors and their families are also leaders in the community, as well as the real political leaders who lead public opinion, as distinguished from "politicians," who are more likely to follow public opinion than lead it.

Employer Leadership Again

The kind of employer leadership is more important than the choice between the two available methods with which he may be confronted. It can make either the collective or the individual method work well. If it is designed to appeal to the financial and few emotional motives of mankind which are both universal and unchanging over the years—if it is long-term and is institutional, not personal and temporary—then either the individual method will operate satisfactorily to employer and employees, customers and public or the collective method will operate better than otherwise, for all parties.

True it may be that poor leadership at the supervisory level can cause labor trouble. But it is also true that good leadership is equally contagious. The employer has the first and best opportunity to furnish sound and considerate leadership to both his supervisors and his employees.

Leadership is easily lost by inattention and neglect. It cannot be intermittent and be acceptable to either supervisor or subordinate. It is good management itself.

I see no reason why a government service department would need to wait for a town meeting to exercise leadership in the employer-employee relationship. It could develop its own personnel policy and practice it. Somebody must start.

I see no need to despair of harmonious employer-employee rela-

tionships. The problem is to give the same attention to this phase of management before frictions start as one would give after frictions arrive.

Discussion

William B. Duffy (North Andover, Mass.). At the superintendents' session there was some discussion about the right of public employees to strike and Mr. Parkinson mentioned that topic. I wonder if he has any possible solution for public employees to bring their grievances before the public—after all the public pays their wages—other than to strike.

Royal Parkinson. I think that you do many times get your message over without strikes. I do not think the strike is the best way of getting it across but it is one of the ways. The voters can act without being hit over the head, I think, if they get the case presented to them well. Their own employers, the supervisors, could furnish leadership, I think, and help them to do it.

PROGRESS REPORT OF THE COMMITTEE ON CATHODIC PROTECTION OF STEEL TANKS AND STANDPIPES

[*Read November 14, 1946.*]

In December, 1941, the Executive Committee of your association appointed five members to a new committee called "Committee on Cathodic Protection of Steel Tanks and Standpipes". The membership of this committee has since been increased to seven, which now includes three of the original five.

In 1942 the application of cathodic protection to water-works structures was new, particularly so in New England, and it was thought best to study recent installations and to get definite experience before attempting to render a report, even of a preliminary nature. Before any real work was started, the clouds of war were gathering over the world and work of this nature was pushed back into the corner to make room for the more important job of getting ready for and winning a war.

During the past months your committee has held several meetings and now submits the following as a progress report.

Theory of Corrosion

Scientists have been at variance for many years as to the causes of corrosion but the world at large is in general agreement that it is an ever-present menace wherever iron and steel are exposed to air and water.

At the present time the generally accepted theory of rust is the so-called "Electro-Chemical Theory". This is a combination of nearly all the theories and, in general, states that, while iron has a tendency to go into solution when in contact with water, it can only go into solution by displacing the hydrogen in the water. The displaced hydrogen forms a thin invisible film on the iron surface and tends to stop further rusting by acting as a barrier between the iron and the water. The film, however, either combines with the free oxygen to form water or escapes as hydrogen gas. As soon as the

hydrogen film disappears, the rusting process starts all over again. The rate of the process is determined by the speed with which the hydrogen is removed. Acid waters cause faster hydrogen formation and faster hydrogen elimination; consequently, the greater the acidity of the water in contact with the iron, the more rapid the rust-forming cycle.

The rust-forming-cycle—the iron replacing the hydrogen in water, hydrogen depositing on the iron surface, the hydrogen escaping and more iron going into solution—takes place in all water, whether neutral or acid. The continuation of the cycle depends upon the rapidity with which the hydrogen film is removed. If the hydrogen film were to remain on the iron surface, rusting would stop or, if some other impervious and stable film could be substituted for the film of hydrogen, the rust cycle would be broken.

Theory of Cathodic Protection

During the past few years, trade journals and papers given before water-works and engineering associations have discussed cathodic protection and the equipment used in connection therewith. It is assumed that the general theory is known to all of us in the water-works profession, so only a brief outline and explanation will be given in this report.

In the simplest sense, cathodic protection consists of stifling the flow of current, which accompanies electro-chemical corrosion, by projecting a current flow through the corroding medium (water) to the metal, where it becomes superimposed on the metal surface to be protected. This is accomplished by suspending elements or anodes in the water and connecting them to a source of direct current, so that the current flows from the electrode to the steel shell of the tank. If the flow of current from this external source is large enough to overcome the potential set up by the reaction of the iron and water, it will prevent the iron of the tank shell from rusting. A thin layer or film of hydrogen will be deposited or plated out on the tank shell and this film will prevent the iron from going into solution. The theory and action are similar to the electro-plating of metals, except that in this case hydrogen is plated onto the surface instead of a metal, as in electro-plating. It has been reported that,

in many cases where the water contains scale-forming salts, a film of calcium or magnesium has been plated out of the water and onto the tank shell. As long as this film remains, whether it is hydrogen or one of the scale-forming salts, adequate and complete protection is obtained.

The source of this direct current is usually a rectifier, constructed so that variations in voltage may be obtained (usually 24 volts maximum).. By changing the voltage, the size, the number or the location of the electrodes, the amount of current flowing to the tank shell can be controlled. It is desirable to have this current flow adjusted so that complete protection is obtained but, from an economical point of view, care must be taken not to apply excess current. This would shorten the life of the electrodes in addition to increasing the current costs.

Manufacturers of Cathodic Protection Equipment

Cathodic protection has been used on oil and gas pipe-lines for years but, as far as your committee knows, the first application to steel water tanks was about 1938. At the present time there are two manufacturers who have made installations in the New England area. These are the Electro Rust-Proofing Corp. of Belleville, N. J., makers of "RUSTOP", and the Johnston & Jennings Co., makers of "RUSTA RESTOR".

Both concerns make the conventional installation, which consists of a rectifier that changes the alternating current supplied by the power company to direct current, this direct current being then applied to the wetted surface of the tank shell. This is accomplished by connecting the positive terminal to the electrodes that are suspended in the water and the negative terminal to the tank shell. In addition, one company makes an electrodeless installation, about which the committee has as yet been able to find little information and less electrical theory to substantiate the claims of the manufacturer.

Questionnaire

In March, 1946, a questionnaire was sent to all listed users of cathodic protection equipment in New England. This list included not only water departments but also manufacturing plants, institu-

tions and power companies that were using elevated steel tanks either for fire protection or general use. The questionnaire was non-technical in scope, as the committee desired a high percentage of returns and was interested primarily in what type of installation they had and if they were satisfied with the results obtained.

As might be expected, the replies ran from "excellent" to "no good". Many reported that they wished more experience before making a positive statement, as their installation had been in for such a short time. In general, the replies were favorable, most of them indicating that they would not go back to their former painting schedule and, should occasion demand, they would purchase additional installations from the same manufacturer. Most of the users recommended the annual service contract, whereby the makers, for an annual fee, service the equipment, remove the electrodes in the winter, if necessary, and make such adjustments, renewals and replacements as are required.

Electrodes

Nearly every conductor of electricity has been used as an electrode but graphite, iron, stainless steel and aluminum are the most common. At the present time we understand that the Johnston & Jennings Co. has developed an electrode made of platinum wire but no replies were received from users of this electrode. The Electro Rust-Proofing Corp. now favors the use of aluminum, since they have found it to be the most satisfactory and economical electrode tried. When considering electrodes it must be remembered that the proper design is very important in obtaining the correct current distribution. A sufficient number of electrodes of adequate length must be used to insure economical current consumption.

Ice Conditions

In New England, where we experience sub-zero weather, ice is a problem. In most installations the electrodes are removed in the winter and replaced in the spring. This is not necessary in elevated tanks used for industrial fire protection, as provision is made for heating the water to keep it above the freezing point. In some of the larger reservoirs, where there is considerable variation in the water

level, ice has not been a problem, the 2.8-mil gal reservoir at Nashua, N. H., being a typical example.

It has been reported to the committee that during the winter months, when the water temperature is low, the rusting action is greatly retarded; in fact, it is claimed by some to be so reduced that it is not necessary to have protection during the winter season. We hope to have a series of tests made to determine the truth of this statement.

Rectifiers

The rectifiers are usually of the copper-oxide or selenium type and are made by General Electric, Westinghouse or some other standard maker of electrical equipment. No trouble was reported from any rectifier but several were changed for a unit of larger capacity.

Current Costs

Many replies did not state the annual cost for electric current. Several reported that they did not have a separate meter for the cathodic protection equipment but they could see little increase in their bill for electricity when the equipment was put into service. Of the 17 actually reporting current costs, they varied from the minimum charge to $175 a year. Variations in the rate paid for power and the size of the tanks make the total annual current costs of little value by themselves. A comparative figure can be obtained only by computing the amount of current applied to each square foot of surface being protected.

None of the replies stated that they considered the cost for current excessive.

General

Copies of the questionnaire, the letter that accompanied it and all replies, along with the tabulation of the replies, are on file with the committee and are available to the members of the association but will not be published in this preliminary report.

Current-Density Requirements

It has been stated by one manufacturer of cathodic protection equipment that their tests show the current density required to

obtain complete protection varies from 1 ampere for each 75 sq ft to 1 ampere for each 3,000 sq ft, depending on the water. In other words, acceptable drinking waters vary so in their characteristics that one water might require up to 40 times as much current to protect each square foot of metal surface as water from another source. The failure to understand this one point has been the cause of most of the errors made in the installations to date.

The current-density (amount of current per square foot) requirement is the most important factor to consider when a cathodic protection installation is made or proposed, since it is the determining factor not only in the original cost of the installation but also in the cost of operation. It is generally agreed that, to protect a bare steel surface in water having no scale-forming salts (most New England waters fall in this class), the current-density requirement varies directly with the free-oxygen content of the water. The pH of the water, within the limits usually found in drinking-water supplies, apparently has little effect on the rate of corrosion.

Most New England waters have a relatively high free-oxygen content, a fact which indicates that they are corrosive and will require a correspondingly high current density to provide complete protection. These waters are also, for the most part, comparatively soft and of low mineral content. Because of this, the resistance to the passage of electrical current is high. These conditions indicate that, as far as cathodic protection is concerned, New England waters provide the worst possible set of conditions to overcome.

Suggested Solution for New England

It has been suggested that probably the most economical and satisfactory solution to our problem here in New England is the combination of an applied protective coating of high electrical resistance together with cathodic protection. In theory, this dual type of protection allows a high current density to be applied to all exposed metal surfaces at a cost relatively low, both from the installation and operating points of view. This dual type of protection is now being used on many of the oil and natural-gas pipe-lines. Asphalts and coal-tar enamels seems to give much better service for this use than paints of the oil-drying type.

Experience at Millbury, Mass.

A good example of this dual type of protection in the water-works field is found at Millbury, Mass. There a 110,000-gallon standpipe, approximately 60 years old, was in very poor condition. In 1935 a cold coat of coal-tar enamel was applied but ice caused the coating to spall badly. In 1938 a gray coat of paint was applied and in 1940 a coat of red lead was added, all in an effort to minimize the corrosion process, but all without marked success, as the leaks continued to develop at the rate of two or three a year. Cathodic protection was applied in 1943 and no further leaks have been observed.

Although the coal-tar enamel was affected by the ice in such a manner that it was no longer suitable as a protective coating in itself, it did reduce the current required to provide complete protection. It is estimated that about 95% of the interior surface is still covered with this coal-tar enamel. While a current density of approximately 1 ampere to each 2,500 to 3,000 sq ft of wetted surface is applied, actually the effective current density is 1 ampere to each 100 to 150 sq ft of bare metal surface. Apparently very satisfactory results are being obtained.

Elevated Tanks Used for Sprinkler Supply

Cathodic protection is ideally suited for installation in elevated steel tanks used to store water for fire protection. In most cases, even though the dissolved oxygen of the water entering the tank is 12 to 13 ppm, it is held in storage only a short time before it drops to approximately 0.8 ppm. This low dissolved-oxygen content requires only a very low current density to insure complete protection.

The Inspection Department of the Associated Factory Mutual Fire Insurance Companies has issued laboratory reports dated February 14, 1941, and January 4, 1944, in which the department approved the cathodic method of corrosion prevention, using the suspended-anode equipment, as furnished and installed by the Electro Rust-Proofing Corp. and the Johnston & Jennings Co. Subsequent inspections and reports indicate that very satisfactory service and protection are being obtained, wherever these installations have been made. Recently the department has conducted an extensive survey

of all tanks under its jurisdiction that are equipped with cathodic-protection apparatus and, while no published report has been received by your committee, it has been reported to us that the results obtained continue to be satisfactory in every way.

The reports stress the fact that cathodic protection only offers protection to the metal surfaces that are submerged in water; all other surfaces, such as the underside of the roof, walls and trusses above the water line, and exterior areas, have to be protected in the conventional manner.

Additional Studies

Four of the committee members have standpipes or reservoirs that are equipped with cathodic protection. They are making a series of tests and measurements, which should provide the association with worthwhile actual knowledge. It might be well to suggest at this point that, if any member has an installation to which he is giving close study, the committee will appreciate a record of the results obtained.

We have contacted the Department of Electrical Engineering at the Massachusetts Institute of Technology and have suggested the advisability of assigning the subject of cathodic protection for thesis work by senior students. We have offered to coöperate with the department by agreeing to arrange for the use of reservoirs and apparatus already installed. Our letter has been acknowledged but as yet no definite arrangements have been made for this work.

Possibly a year from now another report with more detailed information will be available.

Respectfully submitted,

Sidney S. Anthony
Howard E. Bailey
Richard H. Ellis
Harry U. Fuller
Madison H. Goff
William P. Melley
(*Signed*) Donald C. Calderwood, *Chairman*

PROCEEDINGS

NOVEMBER 1946 MEETING

HOTEL STATLER, BOSTON, MASS.

Thursday, November 14, 1946

President Arthur L. Shaw in the Chair.

The President announced that Walter C. Conroy had submitted his resignation as Secretary of the Association and that the Executive Committee had accepted his resignation with a great deal of regret. He further announced that Joseph C. Knox had been appointed Secretary.

Secretary Knox then announced the election of the following new members:

Arsene G. Blaquiere, Superintendent, Water District, Norway, Me.; Donald W. Loiselle, Senior Sanitary Engineer, New Hampshire Health Department, Concord, New Hampshire; Willard P. Sheppard, Water Commissioner, Braintree, Mass.; A. Newton Zahniser, Representative of Wailes Dove-Hermiston Corp., Boston, Mass.; Stanley W. Turner, Superintendent, Water Department, Cotuit, Mass.; Miss Alice M. Keiran, Treasurer, Colebrook Water Co., Colebrook, N. H.

A paper on "Large Gate Valves and Their Operation" was read by Payne Dean, of Payne Dean & Co., Madison, Conn.

A progress report of the Committee on Cathodic Protection of Steel Tanks and Standpipes was read by Donald C. Calderwood, Chairman of the Committee and Superintendent of the Pennichuck Water Works, Nashua, N. H.

DECEMBER 1946 MEETING

HOTEL STATLER, BOSTON, MASS.

Thursday, December 19, 1946

President Arthur L. Shaw in the Chair.

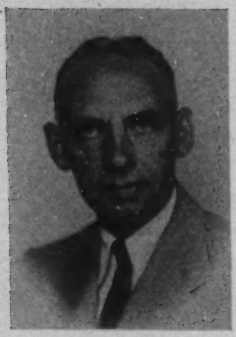
Secretary Knox announced the election of the following new members:

George Gardner, Associate Superintendent, Cotuit Water Department, Santuit, Mass., and Philip B. Streander, Consulting Sanitary Engineer, Boston, Mass.

A paper on "Policy Choices in Employer-Employee Relations" was read by Royal Parkinson, Consultant in Personnel Administration, Boston, Mass.

A paper on "The Use of Activated Carbon in Open Reservoirs" was read by Howard E. Bailey, Consulting Sanitary Engineer, Boston, Mass.

A paper on "Review of the Progress in Break-Point Chlorination" was read by A. E. Griffin, Assistant Director, Technical Service Division, Wallace & Tiernan Co., Inc., Newark, N. J.



JOSEPH C. KNOX

JOSEPH C. KNOX APPOINTED SECRETARY

To succeed Walter C. Conroy, whose resignation was accepted with regret, the Executive Committee on October 17, 1946, appointed Joseph C. Knox Secretary of the New England Water Works Association. Mr. Knox has been an active member of the Association since 1933 and has served on various committees. He was chairman of the Technical Program Committee for four years and in 1945 he was elected a Director of the Association.

Mr. Knox, who is Senior Sanitary Engineer of the Massachusetts Department of Public Health, began his engineering career with that department in 1920. Under the direction of the Chief Sanitary Engineer, Mr. Knox is now in charge of special legislative investigations of the department, including studies of water-supply needs and resources.

In 1937 Mr. Knox received the degree of Master of Science in Sanitary Engineering from Harvard University. During the war he served on the staff of the Adjutant General of Massachusetts, on protection of water utilities and coördination of water-supply material and personnel. He also served as Technical Advisor to the Massachusetts Committee on Public Safety in matters of water supply.

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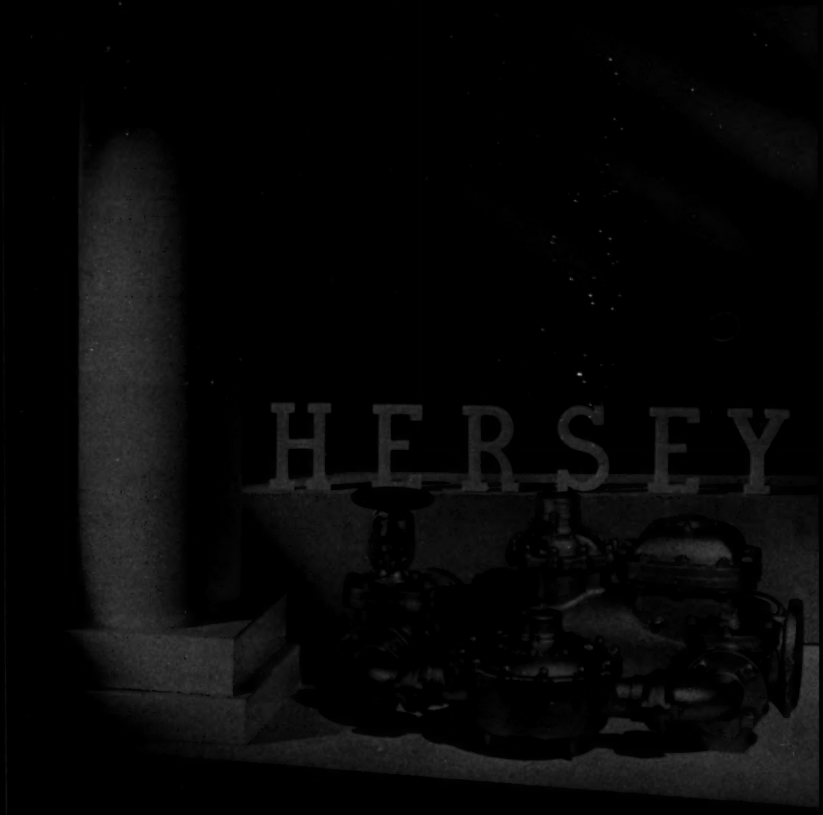

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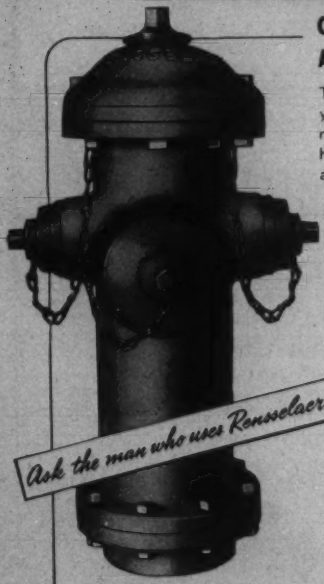

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BUILDERS PROVIDENCE

Instruments

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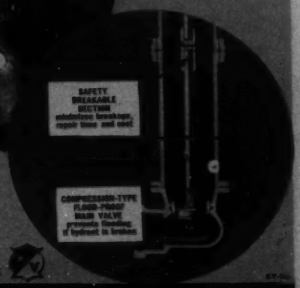

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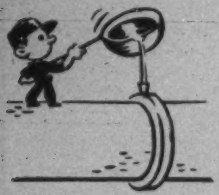

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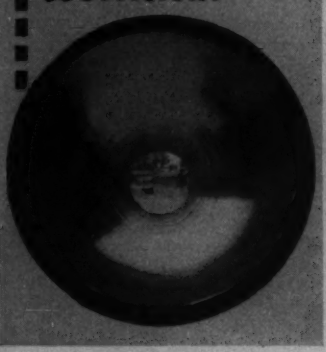

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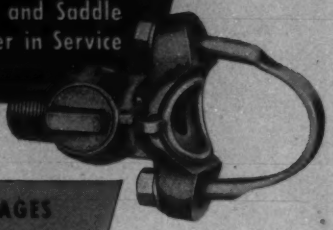
A Combination Corporation Stop and Saddle
That's Simpler to Apply, Stronger in Service



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Distinctive Features of the EDDY Valves

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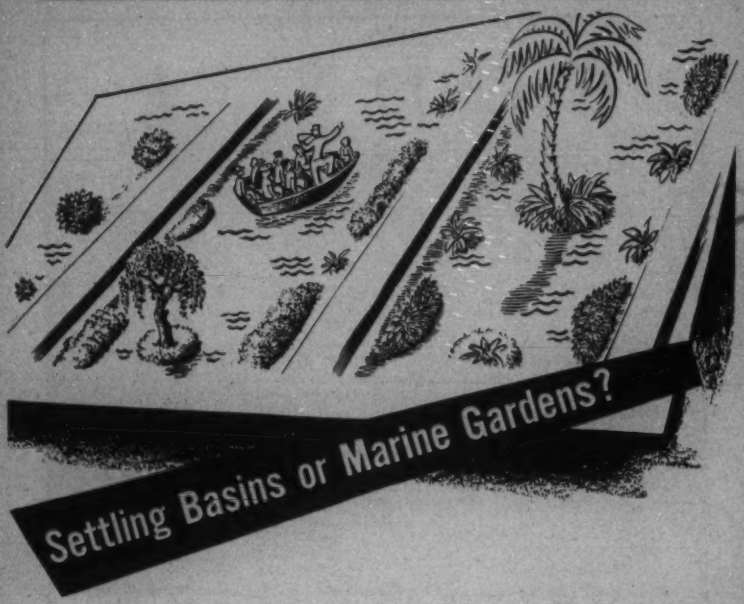

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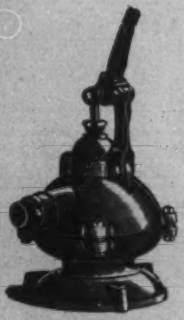
EDSON

PUMPS and ACCESSORIES



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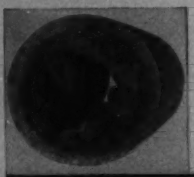

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Combination automatic control both directions through the valve.

Maintains desired discharge pressure regardless of change in rate of flow

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Maintains safe operating pressures for conduits, distribution and pump discharge

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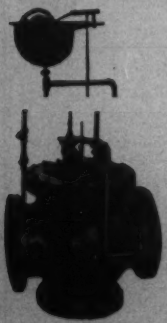

Maintains levels in tank, reservoir or basin

1. As direct acting

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Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

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Fig. 227 Fig. 227A

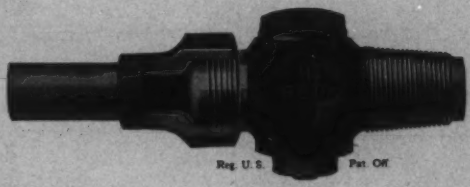

Fig. 438 Corporation and Compression Nut 438-A

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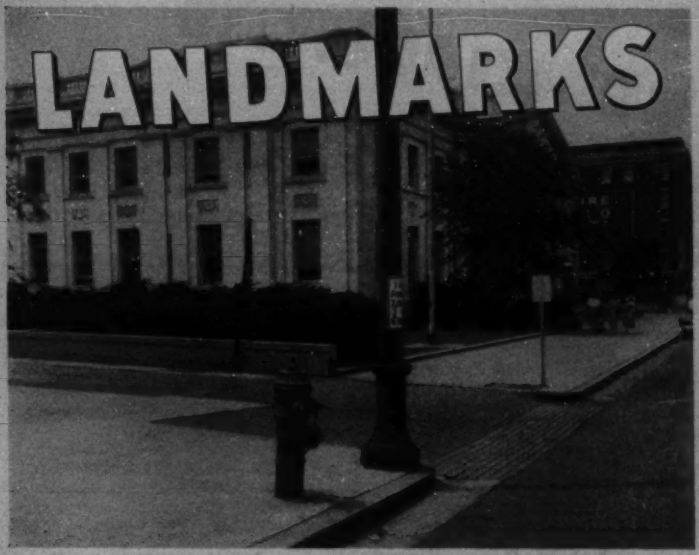

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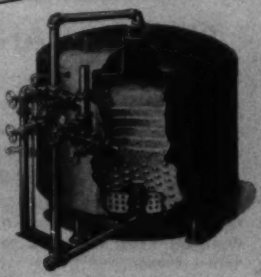

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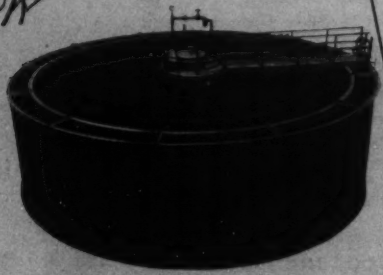

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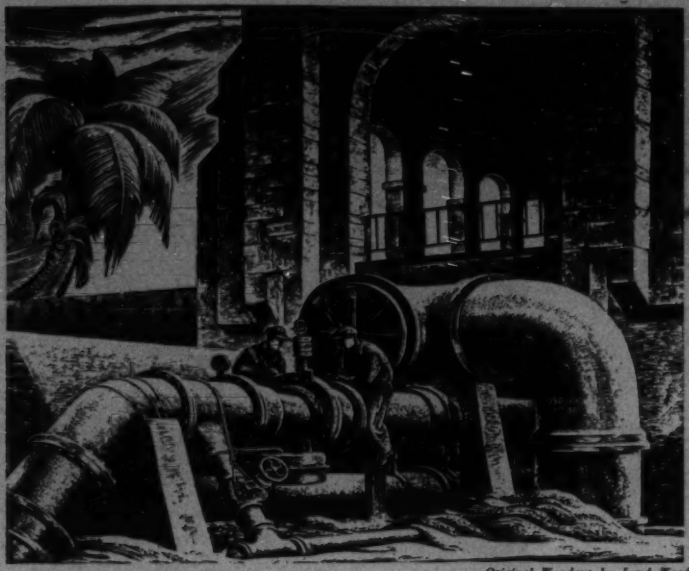

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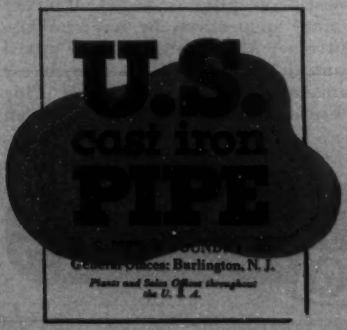

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